CALIFORNIA
ENERGY
COMMISSION

AB 970 NONRESIDENTIAL ALTERNATIVE CALCULATION METHOD APPROVAL MANUAL

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Nonresidential Alternative Calculation Method
Approval Manual

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This AB 970 Nonresidential Energy Calculation Method Approval Manual includes computer programming details that computer programs used to determine compliance with the 2001 AB 970 Energy Efficiency Standards for Nonresidential Buildings must meet. This Manual was adopted at the Energy Commission's January 3, 2001 Business Meeting. This manual is used in conjunction with the Title 24 Building Energy Efficiency Standards (California Code of Regulations, Title 24, Part 6 and the Administrative Regulations, Title 24, Part 1.)

January 4, 2001

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CHAPTER 1. Overview of Process

This Manual explains the requirements for approval of Alternative Calculation Methods (ACMs) used to demonstrate compliance with the Energy Efficiency Standards for nonresidential buildings. The approval process for nonresidential Alternative Calculation Methods (ACMs) is specified in Title 24, Part 1, Chapter 10, Sections 101-110 of the California Code of Regulations. Nonresidential Alternative Calculation Methods (ACMs) are used in the performance approach to demonstrate compliance with the Energy Efficiency Standards for nonresidential buildings as outlined in Title 24, Part 2, Chapter 1, Section 141. The Energy Commission develops and implements the Energy Efficiency Standards.

The Commission approves alternative calculation methods which may be used for demonstrating compliance with the performance approach in the nonresidential standards. This Manual describes the methods and the process for approval of Alternative Calculation Methods (ACMs). It includes the required capabilities, optional capabilities, certification tests, compliance supplement specifications and vendor requirements for ongoing support of the ACM.

Optional capabilities are a special class of capabilities and user inputs that are not required of all programs but may be included in some programs. Some optional capabilities included in this manual have minimal testing requirements. Some optional capabilities not included in this ACM manual may be proposed by vendors. For both these classes of optional capabilities, the Commission reserves the right to disapprove the certification application for a specific optional capability if there is not compelling evidence presented in the public process showing that the optional capability is sufficiently accurate and suitable to be used for compliance for the building standards. In addition, the capability must model energy efficiency measures whose user inputs and installation are readily verified by local enforcement agencies. The Commission's purpose in approving additional optional capabilities is to accommodate new technologies which have only begun to penetrate the market and new algorithms for technologies that the Commission previously judged to be too difficult to model accurately. Optional capabilities which evaluate measures already in relatively common use must have their standard design for the measure based on the common construction practice (or the typical base situation) for that measure since common practice is the inherent basis of the standards for all measures not explicitly regulated. For example, the Commission has no interest in an optional capability that evaluates the energy impacts of dirt on windows unless a new technology produces substantial changes in this aspect of a building relative to buildings without this technology. The burden of proof that an optional capability should be approved lies with the applicant for approval and will be influenced by the ability of the reference computer program, DOE 2.1E to model the optional capability.

Companion documents which are helpful to prepare an ACM for certification include the latest editions of the following Commission publications:

- *~~1998~~ 2001 Energy Efficiency Standards*
- *Appliance Efficiency Regulations*
- *2001 Nonresidential Manual Supplement*
- *1998 Nonresidential Manual for Compliance with the Energy Efficiency Standards*
- *DOE-2.1 California Compliance Supplement*
- *~~1998~~ 2001 Alternative Calculation Manual (ACM) for the Residential Energy Efficiency Standards*
- *Compliance Options Approval Manual for the Building Energy Efficiency Standards*

There are a few special terms that are used in this Manual. The Commission ***approves*** the use of an ACM for compliance. Commission approval means that the Commission accepts the applicant's certification that an ACM meets the requirements of this Manual. The proponent of a candidate ACM is referred to as a ***vendor***. The vendor must follow the procedure described in this publication to publicly certify to the Commission that the ACM meets the Commission's criteria for:

- ***Accuracy*** and ***reliability*** when compared to the DOE-2.1E reference program; and

- ***Suitability*** in terms of the accurate calculation of the correct energy budget, the printing of standardized forms, and the documentation on how the program demonstrates compliance.

In addition to explicit and technical criteria, Commission approval will also depend upon the Commission's evaluation of:

- ***Enforceability*** in terms of reasonably simple, reliable, and rapid methods of verifying compliance and application of energy efficiency features modeled by the ACM and the inputs used to characterize those features by the ACM users.

- ***Dependability*** of the installation and energy savings of features modeled by the ACM. The Commission must evaluate the probability of the measure actually being installed and remaining functional. The Commission must also determine that the energy impacts of the features that the ACM is capable of modeling will be reasonably accurately reflected in real building applications of those features. In particular, it is important that the ACM does not encourage the replacement of actual energy savings with theoretical energy savings due to tradeoffs allowed by an ACM.

For the vendor, the process of receiving approval of an ACM includes preparing an application, working with the Commission staff to answer questions from either Commission staff or the public, and providing any necessary additional information regarding the application. The application includes the four basic elements outlined below. The Commission staff evaluates the ACM based on the completeness of the application and its overall responsiveness to staff and public comment.

The four basic requirements for approval include:

1. Required Capabilities:

    - The ACM shall have certain required input capabilities explained in Chapter 2, and may have optional capabilities such as those outlined in Chapter 3.

    - All Alternative Calculation Methods (ACMs) must pass the required capabilities tests explained in Chapter 5. Alternative Calculation Methods (ACMs) may be approved for additional optional capabilities listed in the certification application. To be certified and approved for any optional capability the ACM must also pass the test(s) for that optional capability.

2. Accuracy of simulation:

    - The ACM shall demonstrate acceptable levels of accuracy by performing and passing the required certification tests discussed in Chapter 5.

      The ACM vendor performs the certification tests in Chapter 5. The vendor conducts the specified tests, evaluates the results and certifies in writing that the ACM passes the tests.

The Commission will perform spot checks and may require additional tests to verify that the proposed ACM is appropriate for compliance purposes.
When energy analysis techniques are compared, two potential sources of discrepancies are the differences in user interpretation when entering the building specifications, and the differences in the ACM's algorithms (mathematical models) for estimating energy use. The approval tests minimize differences in interpretation by providing explicit detailed descriptions of the test buildings that must be analyzed. For differences in the Alternative Calculation Method's (ACM's) algorithms, the Commission allows algorithms that yield equivalent results.

3. Compliance Supplement:

   - The vendor must develop a compliance supplement to their ACM user's manual that meets the specifications presented in Chapter 4.

4. Program Support:

   - The vendor must provide ongoing user and building department support as described in Chapter 6.

The Commission may hold one or more workshops with public review and vendor participation to allow for public review of the vendor's application. Such workshops may identify problems or discrepancies that may necessitate revisions to the application.

Commission approval of Alternative Calculation Methods (ACMs) is intended to provide flexibility in complying with the Energy Efficiency Standards. However, in achieving this flexibility, the ACM must not degrade the standards or evade the intent of the standards to achieve a particular level of energy efficiency. The vendor has the burden of proof to demonstrate the accuracy and reliability of the ACM relative to the reference method and to demonstrate the conformance of the ACM to the requirements of this manual.

1.1 Application Checklist

The following items shall be included in an application package submitted to the Commission for ACM approval:

- **ACM Vendor Certification Statement.** A copy of the statement contained in Appendix A, signed by the ACM vendor, certifying that the ACM meets all Commission requirements, including accuracy and reliability when used to demonstrate compliance with the energy standards.

- **Computer Runs.** Copies of the computer runs specified in Chapter 5 of this Manual on floppy diskettes or other Commission machine readable form as specified in Chapter 5 to enable verification of the runs.

- **Compliance Supplement and User's Manual.** The vendor must submit a complete copy of their ACM User's Manual as well as a complete copy of their ACM Compliance Supplement explained in Chapter 4.

- **Copy of the ACM and Weather Data.** A floppy diskette or other Commission machine readable form copy of the ACM in IBM PC compatible format for random verification of compliance analyses. The vendor must provide weather data for all 16 climate zones or the means to automatically generate the weather data for all of the tests and any compliance run. The ability to generate the weather data used for tests and compliance runs must be integral to the ACM.
- **Weather Data Documentation.** The vendor must submit a copy of the summarized weather data~~e~~ in those instances where their Alternative Calculation Methods (ACMs) use part year weather data rather

than the Commission's standard full year weather data. Such part year weather must be based on the standard Commission full year, hourly weather data. The vendor must include documentation on the methodology used to develop the weather data from the official Commission hourly weather data and a thorough explanation of why this methodology will provide as accurate an estimate of energy use as using the full year, hourly data.

- **Application Fee.** The vendor shall provide an application fee of $1,000.00 (one thousand dollars) as authorized by Section 25402.1(b) of the Public Resources Code, made out to the "State of California" to cover costs of evaluating the application and to defray reproduction costs.

A cover letter acknowledging the shipment of the completed application package should be sent to:

Executive Director
California Energy Commission
1516 Ninth Street, MS-39
Sacramento, CA 95814-5512

Two copies of the full application package should be sent to:

ACM Nonresidential Certification
California Energy Commission
1516 Ninth Street, MS-26~~42~~
Sacramento, CA 95814-5512

Following submittal of the application package, the Commission may request additional information pursuant to Title 24, Section 10-110. This additional information is often necessary due to complexity of many Alternative Calculation Methods (ACMs). Failure to provide such information in a timely manner may be considered cause for rejection or disapproval of the application. A resubmittal of a rejected or disapproved application will be considered a new application, including a new application fee.

1.2 Types of Approval

This Manual addresses two types of ACM approval: Full program approval (including amendments to programs that require approval), and approval of new program features and updates.

If ACM vendors make a change to their programs as described in 1.2.1 or 1.2.2, the Commission must again approve the program. Additionally, any ACM program change that affects the energy use calculations for compliance, the modeling capabilities for compliance, the format and/or content of compliance forms, or any other change which would affect a building's compliance with the Energy Efficiency Standards requires another approval.

Changes that do not affect compliance with the standards such as program changes to the user interface may follow a simplified or streamlined procedure for approval of the changes. To comply with this simpler process the ACM vendor shall certify to the Commission that the new program features do not affect the results of any calculations performed by the program, shall notify the Commission of all changes and shall provide the Commission with one updated copy of the program and User's Manual. Examples of such changes include fixing logical errors in computer program code that do not affect the numerical results (bug fixes) and new interfaces.

1.2.1 Full Approval & Re-Approval of Alternative Calculations Methods (ACMs)

The Commission requires program approval when a candidate ACM has never been previously approved by the Commission, when the ACM vendor makes changes to the program algorithms, or when any other change occurs that in any way affects the compliance results. The Commission may also require that all currently approved Alternative Calculation Methods (ACMs) be approved again whenever substantial revisions are made to the Commission's approval process.

The Commission may change the approval process and require that all Alternative Calculation Methods (ACMs) be approved again for several reasons including:

a) If the standards undergo a major revision that alters the basic compliance process, then Alternative Calculation Methods (ACMs) would have to be updated and re-approved for the new process.

b) If new analytic capabilities come into widespread use, then the Commission may declare them to be required ACM capabilities, and may require all ACM vendors to update their programs and submit them for re-approval.

When re-approval is necessary, the Commission will notify all ACM vendors of the timetable for renewal. There will also be a revised *ACM Approval Manual* published with complete instructions for re-approval.

An ACM program must be re-approved for new optional modeling capabilities when the vendor adds those optional capabilities. The vendor must provide a list of the new optional capabilities and demonstrate that those capabilities are documented in revised user documentation. This may not include computer runs previously submitted.

Re-approval must be accompanied by a cover letter explaining the type of amendment(s) requested and copies of other documents as necessary. The timetable for re-approval of amendments is the same as for full program approval.

1.2.2 Approval of New Features & Updates

Certain types of changes may be made to previously approved nonresidential Alternative Calculation Methods (ACMs) through a streamlined procedure, including implementing a computer program on a new machine and changing executable program code that does not affect the results.

Modifications to previously approved Alternative Calculation Methods (ACMs) including new features and program updates are subject to the following procedure:

- The ACM vendor shall prepare an addendum to the Compliance Supplement or ACM User's Manual, when new features or updates effect the outcome or energy efficiency measure choices, describing the change to the ACM. If the change is a new modeling capability, the addendum shall include instructions for using the new modeling capability for compliance.

- The ACM vendor shall notify the Commission by letter of the change that has been made to the ACM. The letter shall describe in detail the nature of the change and why it is being made. The notification letter shall be included in the revised Compliance Supplement or ACM User's Manual.

- The ACM vendor shall provide the Commission with an updated copy of the ACM and include any new forms created by the ACM (or modifications in the standard reports).

- The Commission will respond within 45 days. The Commission may approve the change, request additional information, refuse to approve the change or require that the ACM vendor make specific changes to either the Compliance Supplement addendum or the ACM program itself.

With Commission approval, the vendor may issue new copies of the ACM with the Compliance Supplement addendum and notify ACM users and building officials.

1.3 Challenges

Building officials, program users, program vendors, Commission staff or other interested parties may challenge any nonresidential ACM approval. If any interested party believes that a compliance program, an algorithm or method of calculation used in a compliance program, a particular capability or other aspect of a program provides inaccurate results or results which do not conform to the criteria described in Section 5.1.4 the party may initiate the challenge of the program. (Please see Section 1.5 Decertification of Alternative Calculation Methods (ACMs) for a description of the process for a challenge.)

1.4 Alternative ACM Tests

Chapter 5 of this Manual contains a series of tests to verify that Alternative Calculation Methods (ACMs) accurately demonstrate compliance. An ACM vendor may propose alternate tests when the vendor believes that one or more of the standard tests are not appropriate for the ACM. The Commission will evaluate the alternate tests and will accept them if they are found to reflect acceptable engineering techniques.

If alternate tests are accepted by the Commission, the tests will be available for use by all Alternative Calculation Methods (ACMs). An alternate test will coexist with the standard test presented in this Manual until the Manual is revised. When a new version of this Manual is produced, the alternative test may be substituted for the current test or may continue to coexist with the original test.

1.5 Decertification of Alternative Calculation Methods (ACMs)

The Commission may *decertify* (rescind approval of) an alternative calculation method through the following means:

- All ACMs are decertified when the standards undergo substantial changes which usually occur every three years.

- Any ACM can be decertified by a letter from the ACM vendor requesting that a particular version (or versions) of the ACM be decertified. The decertification request must briefly describe the nature of the program errors or "bugs" which justify the need for decertification.

- Any "initiating party" may commence a procedure to decertify an ACM according to the steps outlined below. The intent is to include a means whereby unfavorable comparisons with the reference method, serious program errors, flawed numeric results, improper forms and/or incorrect program documentation not discovered in the certification process can be verified, and use of the particular ACM version discontinued. In this process, there is ample opportunity for the Commission, the ACM vendor and all interested parties to evaluate any alleged problems with the ACM program.

NOTE 1: The primary rationale for a challenge is unfavorable comparison with the reference method which means that for some particular building design with its set of energy efficiency measures, the ACM fails to meet the criteria used for testing ACMs described in Section 5.1.4.

NOTE 2: Flawed numeric results where the ACM meets the test criteria used in Section 5.1.4. In particular when an ACM indicates the failure of a building to comply by a significant margin even though the reference method indicates that the building complies - i.e. the reference method has a proposed design building energy budget less than or equal to the standard design building energy budget.

An ACM is allowed to have inputs for energy efficiency measures that it cannot model. The proper method for an ACM to accommodate such inputs and features is for the ACM to automatically ensure compliance failure by a significant margin whenever that feature's inputs are entered by the user. In such cases numeric results are not directly relevant as long as the building fails to comply by an adequate margin. Lighting and receptacle/process loads however must be within the numerically acceptable ranges.

Following is a description of the process for challenging an ACM or initiating a decertification procedure:

1. Any party may initiate a review of an ACM's approval by sending a written communication to the Commission's Executive Director.

   (The Commission may be the initiating party for this type of review by noticing the availability of the same information listed here.)

   The initiating party shall:

   a) State the name of the ACM and the program version number(s) which contain the alleged errors;

   b) Identify concisely the nature of the alleged errors in the ACM which require review;

   c) Explain why the alleged errors are serious enough in their effect on analyzing buildings for compliance to justify a decertification procedure; and,

   d) Include appropriate data on IBM PC compatible floppy diskettes and/or information sufficient to evaluate the alleged errors.

2. The Executive Director shall make a copy or copies of the initial written communication available to the ACM vendor and interested parties within 30 days.

3. Within 75 days of receipt of the written communication, the Executive Director may request any additional information needed to evaluate the alleged ACM errors from the party who initiated the decertification review process. If the additional information is incomplete, this procedure will be delayed until the initiating party submits complete information.

4. Within 75 days of receipt of the initial written communication, the Executive Director may convene a workshop to gather additional information from the initiating party, the ACM vendor and interested parties. All parties will have 15 days after the workshop to submit additional information regarding the alleged program errors.

5. Within 90 days after the Executive Director receives the application or within 30 days after receipt of complete additional information requested of the initiating party, whichever is later, the Executive Director shall either:

a) Determine that the ACM need not be decertified; or,

b) Submit to the Commission a written recommendation that the ACM be decertified.

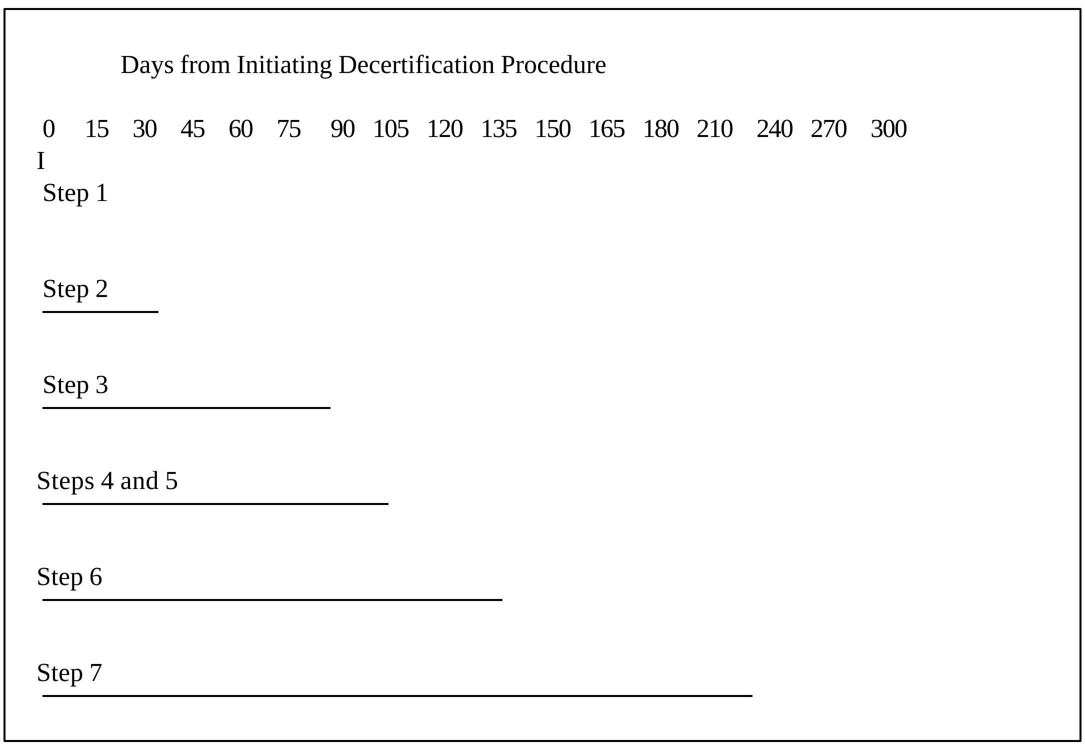
6. The initial written communication, all other relevant written materials and the Executive Director's recommendation shall be placed on the consent calendar and considered at the next business meeting after submission of the recommendation. The matter may be removed from the consent calendar at the request of one of the Commissioners.

7. If the Commission approves the ACM decertification, it shall take effect 60 days later. During the first 30 days of the 60 day period, the Executive Director shall send out a Notice to Building Officials and Interested Parties announcing the decertification.

All initiating parties have the burden of proof to establish that the review of alleged ACM errors should be granted. The decertification process may be terminated at any time by mutual written consent of the initiating party and the Executive Director.

As a practical matter, the ACM vendor may use the 180- to 210-day period outlined here to update the ACM program, get it re-approved by the Commission, and release a revised version that does not have the problems initially brought to the attention of the Commission. Sometimes the ACM vendor may wish to be the initiating party to ensure that a faulty program version is taken off the market.

Figure 1-1: Decertification Timeline



CHAPTER 2. Reference Method and Required Modeling Capabilities for Alternative Calculation Methods (ACMs)

The purpose and policy of this ACM Approval Manual is to specify the California Energy Commission approval process for Alternative Calculation Methods (ACMs) and the assumptions and procedures of the reference method against which ACMs will be evaluated. This manual encompasses the reference method and performance compliance requirements and procedures for nonresidential buildings, hotels & motels, and high-rise residential buildings. A separate ACM Approval Manual covers the performance compliance procedures and requirements for the remaining building types, primarily low-rise residential buildings. The procedures and process described in this manual are designed to preserve the integrity of the performance compliance process relative to a reference method. The reference procedures and method described in this manual establish the basis of comparison for all ACMs. In particular, the approval process described in this manual is designed to ensure that a minimum level of energy efficiency is achieved by all buildings complying with the building energy efficiency standards regardless of the Alternative Calculation Method (ACM) used. This is accomplished by having the ACM meet certain test criteria for a series of ACM/Reference Method comparison tests, by specific input and output requirements for all ACMs, and by vendor-certification of the ACM's conformance to the requirements in this manual. This chapter describes the reference procedures for use with the *reference computer program*, (the reference calculation engine), *version ~~86~~110 of DOE 2.1E* public domain computer program from the Lawrence Berkeley Lab, and the specific aspects of the reference method that are required for all ACMs.

In this manual the term "standards" means the building energy efficiency standards, Title 24, Part 6, Chapter 1 of the California Code of Regulations. The term "compliance" means that a building design in an application for a building permit complies with the "standards" and meets the requirements described for building designs therein. As indicated above, the term ACM stands for Alternative Calculation Method.

This Chapter specifies the reference procedures for the required capabilities that an ACM will be tested for and also specifies how the reference computer simulation program will be used to model the features. All of the required capabilities are described in terms of the capabilities and algorithms of the Commission's reference program. An ACM must account for the effects of all of the features described in this chapter on a building's energy.

The modeling procedures and assumptions for each capability are for both the *standard* and *proposed designs*. The requirements for the standard design include those that ACMs must apply to new features, altered existing features, unchanged existing features or all of the above. In order for a program to become certified, it must, at a minimum, accept all of the required inputs and meet the test criteria when compared against the reference computer program using procedures and assumptions as required in the sections describing the capabilities.

2.1 Compliance - Required Capabilities

2.1.1 Type of Project Submittal

ACMs must require the user to identify the type of project for which compliance is being demonstrated. These ACMs must require the user to choose one of the following options:

- New Building
- Addition Alone (modeled as new building but labeled on output)
- Addition Plus Alteration of Existing Building
- Alteration of Existing Building

These input options are required even though the ACM may not have the capability of performing any existing building analysis. Any ACM without the capability of analyzing existing building alterations with or without an addition must inform the user that the ACM cannot analyze alterations in existing buildings and that the ACM must go into a noncompliance mode when the user selects a type of project it is incapable of analyzing. This precludes any compliance output for such cases. Special calculation and reporting for ACMs with automated analysis of additions and alterations are required and are covered in Section 3.1--Optional Compliance Capabilities-- and Section 2.7--Required Standard Reports.

2.1.2 Scope of Compliance Submittal

For each building or separately permitted space, ACMs must also require the user to identify the scope of the compliance submittal from the following list:

- Envelope only
- Mechanical only
- Envelope and Lighting
- Envelope and Mechanical
- Lighting and Mechanical
- Envelope, Lighting and Mechanical

Each of these situations requires specific assumptions, input procedures and reporting requirements. These requirements are documented in either Chapter 2--Required Loads Capabilities and Required Systems and Plant Capabilities-- and Chapter 4--Compliance Supplement. **ACMs must only produce reports specific to the scope of the submittal determined for the run.** Hence an Envelope Only scope run is only allowed to produce ENV forms and PERF forms that are designated **Envelope Only** and the tabulated total number of pages printed on the output must be consistent with this limited output requirement.

The information about installed service water heating system(s) is included in the mechanical compliance submittal forms. ACMs must calculate the energy use for both the proposed system(s) and the reference system(s) [energy budget] and provide the results on the PERF forms. The energy budget is calculated in accordance with Section 2.5 (Service Water Heating--Required capabilities) of this manual. If the energy used by the proposed water heating system(s) is less than the energy budget, the credit may be traded off for other building features. Alternatively, for high-rise residential buildings, users may show service water heating compliance by meeting the prescriptive requirements of Section 151(f)(8~~9~~) of the standards. When the compliance for the service water heating is shown prescriptively, tradeoff between the service water heating and other building components is not allowed.

When a building has a mixed scope of compliance, such as a speculative building where all the envelope is being permitted but the core includes lighting as well as portions of the envelope, **two** (or more) compliance runs must be performed and forms from different runs must be submitted for the appropriate spaces. The scope of submittal for the building core compliance run will be **Envelope & Lighting** and the scope of submittal for the compliance run for the remainder of the building will be **Envelope Only**.

2.1.3 New Building or Addition Alone

ACMs are required to be able to perform compliance on new buildings and additions as if they were new (or newly conditioned), stand-alone, buildings. ACMs may do this by treating an addition alone as a new building, but an addition modeled in this way must be reported on all output forms as a **Stand Alone Addition.**

2.1.3.1 Partial Permit Applications

Description: ACMs must require the user to input the components of the building for which a permit is being requested. Building components are Envelope, Mechanical, and Lighting. In a partial permit application one or more of the following conditions may occur:

1. No envelope compliance (no envelope submittal)
2. No mechanical compliance (no mechanical submittal)
3. No lighting compliance (no lighting submittal)

Assumptions for each of these conditions for both the *standard* and *proposed design* are described below.

Note: A partial permit application involving no envelope compliance creates an exceptional condition. This requires either a copy of the previous envelope compliance approval or an equivalent demonstration by the applicant (to the satisfaction of the local enforcement agency) that the building is conditioned and an occupancy permit has previously been issued by the local enforcement agency.

The exceptional condition list must indicate the presence of an existing or previously-approved envelope documentation and form must be produced to document the existing envelope. No envelope (ENV) compliance forms may be output as part of the compliance output when the user selects this option.

Modeling Rules for Proposed Design:

No envelope compliance. The envelope shall be modeled according to the as-built drawings and specifications of the building or as it occurs in the previously-approved compliance documentation of the building. All envelope features and inputs required for ACMs by this manual must be entered.

No mechanical compliance. ACMs shall model default heating and cooling systems according to the rules in Section 2.4.2.26 (Modeling Default Heating and Cooling Systems). ACMs may not allow the entry of an HVAC system and must automatically model the default system. Economizer controls will be modeled as indicated in the Standard Design Assumptions for Air Economizers based on system total (sensible + latent) cooling capacity.

No lighting compliance. Previously-approved lighting plans with approved lighting compliance forms may be entered as Tailored Lighting at the approved lighting power levels shown in the construction and previously-approved compliance documents and installed as approved. The exceptional conditions list on the PERF-1 form must indicate that previously-approved lighting plans and compliance forms must be resubmitted with the application.

In the absence of approved lighting plans and lighting compliance forms, the ACM shall model the lighting system according to Section 2.3.2.1 (Lighting) using the rules for *Lighting compliance not performed.*

Modeling Rules for Reference Design (All):

No envelope compliance. The envelope shall be identical to the proposed design.

No mechanical compliance. The mechanical systems shall be identical to the proposed design.

No lighting compliance. With previously approved lighting plans, the lighting levels for each space shall be equal to the approved design. No lighting (LTG) compliance forms may be output with the compliance output. The local enforcement agency should verify that the lighting has already been approved and installed or, if recently designed and approved, should verify the independent lighting approval.

In the absence of approved lighting plans and lighting compliance forms, the ACM shall model the lighting system according to Section 2.3.2.1 (Lighting) using the rules for *Lighting compliance not performed.*

2.1.4 Climate Zone

The program must account for variations in energy use due to the effects of the sixteen (16) California weather/climate zones. Weather/Climate information for the compliance simulation is derived from one of sixteen (16) different data sets for the sixteen climate zones. These sixteen climate zone weather data sets are the official weather data for each zone and hourly data from other weather tapes may not be used for compliance purposes (see Section 2.6). However, the data from these tapes may be adjusted to local conditions by methods approved by the Commission or by the reference method (see Appendix C) that adjusts for local design temperature extremes . **The same weather data must be used for the standard and proposed designs.** The ACM must use climate data and accept input for latitude, longitude and elevation of the weather file which will be used by the reference program and method to determine compliance. The reference method uses a full 8760 hour year of hourly data. ACMs must either use the hourly data based on the CECREV2 ASCII data or summarized, sampled, or averaged data consistently derived from the CECREV2 ASCII hourly data files as long as the ACM passes the test criteria for all minimum tests.

2.1.5 Reference Year

The 1991 calendar year must be used as the basis for the frequency and timing of the occurrence of holidays, Saturdays and Sundays. The reference method observes the holidays listed in Section 2.3.3.3 of this manual. This is a fixed compliance input that must be the same for both the standard and proposed designs. The reference method uses CECREV2 hourly data in WYEC format for the sixteen climate zones. Weather data is available in DOE compressed format for the reference computer simulation program along with programs to produce weather data from these files customized to the design weather data for each city in California. The weather data is also available in archived ASCII format for all 8760 hours for each of the 16 climate zones.

Developers of ACM programs may request an electronic copy of the weather data and programs to customize the weather information for each city in California by writing to:

California Energy Commission
Energy Efficiency Division
Attention: Nonresidential ACM Manual
1516 Ninth Street, MS-26~~42~~
Sacramento, California 95814

2.1.6 Output Reports

Compliance output is highly restricted in quantity and format. All non-default inputs **must** be reflected directly in the output. This can also be accomplished by changes in directly-related output values and the forms reflecting those changes **must** be printed when any compliance output forms are selected. Exceptional user entries or values outside of "normal" ranges must be printed and must be clearly flagged in the output so that the plan checker and field checker can and will readily note these user entries or values. Exceptional user entries include such entries as process loads, tailored ventilation, and tailored lighting and modifications to certain default values specified herein. When the user enters such exceptional input in a compliance run, the ACM must automatically print the forms containing such user inputs and exceptional conditions must be indicated on the PERF-1 form as part of the special conditions verification checklist for the plan checker and field inspector. This verification list must **COMMAND THE ATTENTION** of anyone reviewing the output and must be included with all performance compliance submittals even if no exceptional conditions are reported. In particular exceptional inputs **must** be reflected on the relevant ENV, MECH, or LTG forms **and** the PERF-1 Form and the forms showing these exceptional entries **must** be printed when any compliance output forms are selected.

For a compliance documentation run, the ACM must automatically determine the forms to be printed and the total number of pages (T) required to print those forms and must print exactly that number of pages and all ACM-determined forms. This determination must be made based on the user's description of the scope of compliance, the building characteristics, and the user's selection of a compliance run. ACMs may not allow the user to select specific forms to be printed in a compliance run (as distinguished from a diagnostic run) where printed or disk compliance output is requested. Each page (N) of the required output must indicate Page N of T in the page header, the unique compliance runcode and the initiation time of the compliance run. The PERF-1 must list or indicate all of the forms required for a valid submittal, including those required to be done by hand.

Diagnostic information not directly related to compliance or required to be reported by this manual **shall not be printed or output in printer format** for a compliance documentation run. ACMs may have a separate type of diagnostic output for the user's use but it must be distinctly different from compliance output. Distinctly different means that diagnostic output could not be confused with compliance output by a plan checker. At a minimum, diagnostic output shall **not** use form headers or output formats similar to compliance forms.

2.1.7 Certification Testing

A specific set of compliance comparison tests to evaluate ACMs are described in Chapter 5. Using these tests, the difference between the reference method's compliance margins and an ACM's compliance margins will be subjected to specific test criteria. These test criteria must be met for every test. The test criteria are designed to minimize the possibility that an approved ACM will determine that a specific proposed building complies with California's building energy efficiency standards when the reference method would determine otherwise. The test criteria **specifically do not** prevent an ACM from being conservative with regard to compliance but requires the ACM to produce results similar to those of the Commission’s reference program. In addition to satisfying the test criteria, the ACM must conform to all of the input and output requirements described in this manual and some calculation procedural requirements that all ACMs must meet.

These tests simultaneously exercise various ACM analytical capabilities and various aspects of the custom budget process relative to the reference program and the official reference custom budget procedures. To qualify for approval for compliance use, an ACM must have compliance margins that meet specified acceptance criteria relative to the reference procedures' compliance margins for each and every specified test.

An ACM may use these procedures directly or they may use procedures that are similar to these procedures or procedures that approximate the reference method results with sufficient accuracy to meet the criteria described in Chapter 5 for the minimum capability tests. In particular, when this manual uses the term **ACMs must model** it means that ACMs must be able **to quantitatively approximate** the changes in energy use due to particular envelope, lighting, or HVAC features of a building in such a way that the ACM is capable of meeting all test criteria in Chapter 5 for each and every test. All ACM estimates for lighting and receptacle energy use must be within a few percent of the reference method results. ACMs, however, **must also be capable of accepting appropriate inputs and producing the required outputs subject to the limitations** described in this chapter and elsewhere in this manual to be approved for compliance purpose

2.2 Building Shell - Required Capabilities

All ACMs must receive inputs for each different opaque surface (wall, roof/ceiling, or floor) that separates the conditioned space from the unconditioned or semi-conditioned space or the ground, including each demising wall (which consequently includes each party wall.) These inputs include construction framing type, orientation and tilt, location and area for each exterior surface. An ACM must also allow the user to enter inputs to determine heat transfer and heat capacity characteristics of exterior opaque surfaces for the proposed design. The heat capacity of standard design exterior surface is identical to the heat capacity of the proposed design exterior surface. Based on this heat capacity, the standards specify a required ~~U-value~~U-factor for the exterior surface that is used as the heat transfer characteristic for the standard design exterior surface.

For all exterior surfaces/assemblies it is assumed that the ~~U-value~~U-factors listed in the building standards include an exterior air film R-value of 0.17 h-ft^2-^{o}F/Btu, which the reference method strips off and replaces with a simulated outside air film resistance. Azimuthal orientation and tilts of surfaces must be entered to the nearest degree.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being “All”. An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as “All”.

All ACMs must separately report information about demising walls, fenestration in demising walls, exterior walls, and fenestration in exterior walls. Demising walls and demising wall fenestration separate conditioned spaces from enclosed unconditioned or semi-conditioned spaces. Party walls are always considered to be demising walls when they separate spaces controlled or occupied by different tenants. For the purpose of compliance, the adjacent enclosed spaces not controlled by the tenant of the given space or by a single manager of the building are unconditioned. This assumption means that party walls are treated as demising walls and adjacent tenant spaces are modeled as enclosed unconditioned spaces. To avoid modeling adjacent spaces that are not part of the permit, for purposes of standards compliance, an ACM must assume that the demising wall is adiabatic and no heat transfer occurs through it. **In this manual, the word “unconditioned” is used to refer to both unconditioned and semi-conditioned spaces**.

2.2.1 Construction Assemblies

2.2.1.1 Construction Identifiers

Description: A unique alphanumeric identifier describing each construction type. Separate identifiers must be used to refer to proposed and standard designs of the same construction type.

2.2.1.2 Heat Capacity

Description: The ability of a construction assembly to absorb thermal energy. The heat capacity, HC, of an assembly is calculated by using the following equation:

$$HC = \sum_{i=1}^{n} (\rho_i \times c_i \times t_i)$$

where:

n is the total number of layers in the assembly
ρ_i is the density of the i^{th} layer
c_i is the specific heat of the i^{th} layer
t_i is the thickness of the i^{th} layer

all in consistent units.

For framed assemblies where the insulation layer also includes framing members, ACMs must calculate the heat capacity of the framing/insulation layer based on weighted average density and specific heat of the framing and insulation.

DOE Keyword: DENSITY
SPECIFIC-HEAT
THICKNESS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall calculate the overall *heat capacity* of a construction assembly according to the above formula using the layers as they occur in the construction documents. Alternatively, ACMs may require an explicit input for the assembly's overall *heat capacity*.

User Input: Yes, or may be calculated by the program according to the above formula.

Low Caution: ACMs must output a warning note on the ENV-1 form if the user specified or calculated overall HC is less than 0.6 Btu/ft^2-^{o}F.

Modeling Rules for Reference Design (All): ACMs shall determine standard design assemblies from the overall *heat capacity* of the proposed construction assembly. The heat capacity of the reference construction assembly shall be the same as the heat capacity of the proposed assembly.

2.2.1.3 Construction Types

Description: Exterior walls have the following five construction types: (1) wood framing; (2) steel framing; (3) medium-mass masonry with 7.0≤HC<15.0 Btu/ft^2-^{o}F; (4) heavy-mass masonry with HC≥15.0 Btu/ft^2-^{o}F; (5) other; and (6) composite. Exterior floors and soffits have the following two construction types: (1) light-mass with HC<7.0 Btu/ft^2-^{o}F; and (2) medium or heavy-mass with HC≥7.0 Btu/ft^2-^{o}F. All exterior roofs and ceilings are of the same type.

2.2.1.4 Absorptance

Description: The fraction of the incident solar radiation absorbed as heat on the construction assembly's opaque exterior surface.

DOE Keyword: ABSORPTANCE

Input Type: Default

Tradeoffs: ~~Neutral~~Yes

Modeling Rules for Proposed Design: ~~The ACM must either receive use user input for the absorptance of each opaque exterior surface or use the default value.~~

For roofs, qualifying cool roofs shall model an absorptance of 0.45. All other roofs shall use the default value.

For other opaque surfaces, the ACM must either receive user input for the absorptance of each opaque exterior surface or use the default value.

~~value.~~

Cool Roof Value: Roof = 0.45

To qualify as a cool roof the roof must meet the requirements of Section 118 of the Standard, which states:

(a) Effective January 1, 2003, a roof shall be considered a cool roof if the roof is certified and labeled according to requirements of Section 10-113 and if the roof meets conditions (1) or (2) below. Prior to January 1, 2003, manufacturer's published performance data shall be acceptable to show compliance with one of the following conditions.

(1) Roof of concrete tile (per ASTM C55-99) and clay tile (per ASTM C1167-96) require a minimum initial total solar reflectance of 0.40 when tested in accordance with ASTM E903 or E1918, and a minimum thermal emittance of 0.75 when tested in accordance with ASTM E408.

(2) All other roofs require a minimum initial total solar reflectance of 0.70 when tested in accordance with ASTM E903 or E1918, and a minimum thermal emittance of 0.75 when tested in accordance with ASTM E408.

(3) Liquid applied roofing products shall be applied at a minimum dry mil thickness of 20 mils across the entire roof surface, and meet the minimum performance requirements of ASTM D6083-97 when tested in accordance with ASTM D6083 97 for the following key properties:

** Initial Tensile Strength*
** Initial Elongation*
** Elongation After 1000 Hours Accelerated Weathering*
** Permeance*
** Accelerated Weathering*

Default: Roof = 0.70
Exterior wall = 0.70

Demising wall = 0.05

Low Value: Exterior wall = 0.20
Demising wall = 0.02

High Value: Exterior wall = 0.90
Demising wall = 0.80

Cool Roof Caution Warning on PERF-1 if a cool roof credit is claimed.

Low Caution: Warning on PERF-1 that the absorptance of an exterior wall is less than 0.50

Modeling Rules for Reference Design (All): ~~For the reference method, the absorptance of each opaque exterior surface is the same as the proposed design.~~
For the reference method, the roof absorptance shall be modeled at 0.70. The absorptance of each other opaque exterior surface is the same as the proposed design.

2.2.1.5 Surface Emissivity

Description: The ratio of radiation intensity from the construction assembly's opaque exterior surface to the radiation intensity at the same wavelength from a blackbody at the same temperature.

DOE Keyword: OUTSIDE-EMISS

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The proposed design shall model a surface emissivity of 0.90.

Modeling Rules for Reference Design (All): The surface emissivity of the reference design shall be the same as the surface emissivity of the proposed design.

2.2.1.6 Wood Frame

Description: A construction assembly that consists of wood framing members, insulation or air in the cavity between the framing members with exterior and interior finish.

DOE Keyword: EXTERIOR-WALL
LAYERS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Wood-framed assemblies consist of a framing section and a cavity section. ACMs shall calculate the overall R-value of the assembly using ASHRAE Parallel Path method and the following framing percentages:

Walls: *F*raming percentages for frame spacing of 16" O.C., 24" O.C., and 48" O.C. are 15%, 12%, and 8% respectively.

Floors/soffits and roofs/ceilings: The framing percentage for frame spacing of 16" O.C. and 24" O.C. are 10% and 7% respectively.

Using the above calculated overall R-value, ACMs shall determine the equivalent cavity insulation/framing R-value that would result in the same overall R-value for the assembly when all assembly layers including the insulation/framing layer are added as a series of homogeneous layers. The heat capacity of the cavity insulation/framing shall be the volume weighted average of the cavity insulation and the framing.

Modeling Rules for Reference Design (New & Altered Existing): The standard design wall and floor/soffit assemblies are dependent on the HC of the proposed assembly. For wall, floor/soffit, and roof/ceiling assemblies, an ACM must require the user to enter values needed to determine heat capacity, HC, for the proposed design and use it to determine the standard design ~~U-value~~U-factor.

ACMs must model standard design wall assemblies using the same **wood frame construction,** layers, and modeling technique as the proposed wall assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the Standards for wood-framed walls and the applicable climate zone.

ACMs must model standard design floor/soffit assemblies using the same **wood frame construction,** layers, and modeling technique as the proposed floor/soffit assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the Standards for "other" and the applicable climate zone.

ACMs must model standard design roof/ceiling assemblies using the same **wood frame construction,** layers, and modeling technique as the proposed roof/ceiling assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the standards and the applicable climate zone.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall model each existing wood-framed assembly as they occur in the existing building using the same procedure as described above.

2.2.1.7 Steel Frame

Description: A construction assembly that consists of steel framing members, insulation or air in the cavity between the framing members with interior and exterior finish.

DOE Keyword: EXTERIOR-WALL
LAYERS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Steel-framed assemblies consist of a framing section and a cavity section. ACMs shall calculate the overall R-value of the assembly using ASHRAE Zone Method and the following framing percentages:

*Walls: F*raming percentages for frame spacing of 16" O.C., 24" O.C., and 48" O.C. are 15%, 12%, and 8% respectively.

Floors/soffits and roofs/ceilings: The framing percentage for frame spacing of 16" O.C. and 24" O.C. are 10% and 7% respectively.

The calculated overall R-value of the assembly shall be within 10 percent of the overall R-value calculated by the EZFRAME program.

Using the above calculated overall R-value, ACMs shall determine the equivalent cavity insulation/framing R-value that would result in the same overall R-value for the assembly when all assembly layers including the insulation/framing layer are added as a series of homogeneous layers. The heat capacity of the cavity insulation/framing shall be the volume weighted average of the cavity insulation and the framing.

Modeling Rules for Reference Design (New & Altered Existing): The standard design wall and floor/soffit assemblies are dependent on the HC of the proposed assembly. For wall, floor/soffit, and roof/ceiling assemblies, an ACM must require the user to enter values needed to determine heat capacity, HC, for the proposed design and use that same value of heat capacity for the standard design.

ACMs must model standard design wall assemblies using the same **steel frame construction,** layers, and modeling technique as the proposed wall assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the Standards for steel-framed walls and the applicable climate zone.

ACMs must model standard design floor/soffit assemblies using the same **steel frame construction,** layers, and modeling technique as the proposed floor/soffit assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the Standards for "other" and the applicable climate zone.

ACMs must model standard design roof/ceiling assemblies using the same **steel frame construction,** layers, and modeling technique as the proposed roof/ceiling assembly. An ACM shall adjust the cavity insulation in order for the overall ~~U-value~~U-factor of the standard assembly to match the ~~U-value~~U-factor requirement listed in Table 1-H or 1-I of the standards and the applicable climate zone.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall model each existing steel-framed assembly as they occur in the existing building using the same procedure as described above.

2.2.1.8 Masonry

Description: A construction assembly that consists of masonry materials such as poured concrete, solid brick, fully grouted masonry units, or perlite filled hollow concrete masonry blocks.

DOE Keyword: EXTERIOR-WALL
LAYERS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model masonry assemblies as a single construction using ASHRAE Table 4 in ASHRAE Handbook, 1997, Fundamentals Volume, Chapter 24.

Modeling Rules for Reference Design (New & Altered Existing): The standard design wall and floor/soffit assemblies are dependent on the HC of the proposed assembly. For wall, floor/soffit, and roof/ceiling assemblies, an ACM must require the user to enter values needed to determine heat capacity, HC, for the proposed design and use that same value of heat capacity for the standard design.

ACMs must determine the standard design wall assemblies using homogeneous **masonry** material with a ~~U-value~~U-factor matching the requirement listed in Table 1-H or 1-I of the Standards for the applicable HC range and the climate zone.

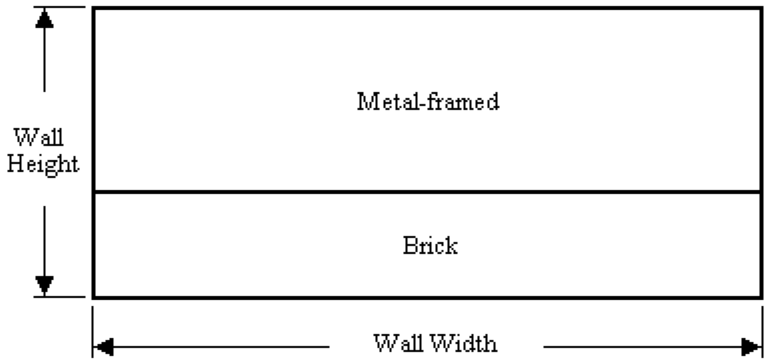
ACMs must determine the standard design raised floor/soffit assemblies using homogeneous **masonry** material with a ~~U-value~~U-factor matching the requirement listed in Table 1-H or 1-I of the Standards for HC ≥ 7.0 and the applicable climate zone. For high-rise residential buildings and guest rooms of hotel/motel buildings **ACMs must adjust the listed ~~U-value~~U-factor for raised floor/soffit assemblies for climate zones that require insulation as indicated in Table 1-I**.

ACMs must determine the standard design roof/ceiling assemblies using homogeneous **masonry** material with a ~~U-value~~U-factor matching the requirement listed in Table 1-H or 1-I of the Standards and the applicable climate zone.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall model each existing masonry assembly as they occur in the existing building using the same procedure as described above.

2.2.1.9 Composite Walls

Description: Exterior wall assemblies that consist of any combination of wood framing, steel framing, masonry, and other types of wall construction assemblies. An example of a composite wall made up of a masonry section and a steel-framed section is shown below:



DOE Keyword: EXTERIOR-WALL
LAYERS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model each type of construction in a composite wall shown in the construction documents as described above.

Modeling Rules for Reference Design (New & Altered Existing): For each construction type of the composite wall ACMs shall use the applicable technique to model the standard design. The ~~U-value~~U-factor of each type must match the applicable requirements of Table 1-H or 1-I of the Standards for the applicable HC range and the climate zone.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall model each existing composite wall as it occurs in the existing building using the procedure described above.

2.2.2 Above-Grade Envelope

2.2.2.1 Exterior Partitions

Description: Above-grade exterior partitions that separate conditioned spaces from the ambient air, unconditioned attic spaces and crawl spaces, courtyards, or unconditioned spaces that are not enclosed. Exterior walls, raised floors, roofs, and ceilings are exterior partitions.

The area of exterior partitions is defined by specifying the width of the partition and a height equal to the total height of the floor.

DOE Keyword: HEIGHT, WIDTH

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each exterior partition of each floor, ACMs shall receive inputs for the height and width as they occur in the construction documents.

Modeling Rules for Reference Design (All): The standard design shall model each exterior partition with the same height and width as the proposed design.

2.2.2.2 Surface Azimuth of Exterior Partitions

Description: The direction of an outward normal projecting from the partition's exterior surface relative to the true north. Positive azimuth is measured clockwise from the true north.

DOE Keyword: AZIMUTH

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: Azimuth of each exterior partition shall be input as shown in the construction documents for the building to the nearest whole degree.

Modeling Rules for Reference Design (All): The azimuth of each exterior partition shall be modeled in the same manner as it occurs and is modeled in the proposed design.

2.2.2.3 Surface Tilt of Exterior Partitions

Description: Inclination of a partition's exterior surface from horizontal.

DOE Keyword: TILT

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The tilt of each exterior surface shall be input as shown in the construction documents for the building to the nearest whole degree.

Modeling Rules for Reference Design (All): The tilt of each exterior surface shall be modeled in the same manner as it occurs and is modeled in the proposed design.

2.2.2.4 Construction of Exterior Partitions

Description: The construction assembly describing the exterior partition. The modeling rules are described in Section 2.2.1--Construction Assemblies.

2.2.2.5 Demising Partitions

Description: A barrier that separates a conditioned space from an enclosed unconditioned space. "Party walls" separating tenants, a partition separating a conditioned space from an unconditioned warehouse, and a glass partition separating a conditioned space from an unconditioned sunspace are examples of demising partitions.

DOE Keyword: INTERIOR-WALL
HEIGHT
WIDTH
NEXT-TO

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference design shall model demising partitions as adiabatic interior partitions. No heat transfer shall occur between the two adjacent spaces.

ACMs must require the user to input information for each demising partition including orientation and tilt, location, size, shape and construction as they occur in the construction documents. Window Management shall not be modeled for fenestration products separating conditioned and enclosed unconditioned spaces.

ACMs shall indicate in the compliance forms that demising partitions are used to separate the conditioned space from the unconditioned space. For framed demising partitions in a new construction, the compliance forms shall also indicate that R-11 insulation must be installed.

Modeling Rules for Reference Design (All): The standard design shall model each demising partition with the same thermal characteristics, orientation and tilt, location, size, shape and construction as the proposed design.

2.2.2.6 Interzone Walls

Description: The reference method shall model heat transfer through interior walls separating directly conditioned zones from other directly and indirectly conditioned zones as air walls. The reference program accounts for the thermal mass of interior walls as described in Section 2.2.2.13.

DOE Keyword: INTERIOR-WALL
WIDTH
HEIGHT
NEXT-TO

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall receive inputs for the width and height (or area) of all interzone walls as they occur in the construction documents. The reference program shall model interzone walls as air walls with zero (0) heat capacity and an overall ~~U-value~~U-factor of 1.0 Btu/h-ft^2-^{o}F.

Modeling Rules for Reference Design (All): The reference method models all interzone walls as they occur (and as they are modeled) in the proposed design.

2.2.2.7 Interior Floors

Description: The reference method shall model heat transfer through interior floors separating directly conditioned zones from other directly and indirectly conditioned zones.

DOE Keyword: INTERIOR-WALL
WIDTH
HEIGHT
NEXT-TO

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall receive inputs for the all interior floors as they occur in the construction documents.

Modeling Rules for Reference Design (All): The reference method models all interior as they occur (and as they are modeled) in the proposed design.

2.2.2.8 Return Air Plenums

Description: Return air plenums are considered conditioned spaces and must be modeled as part of the adjacent conditioned space.

2.2.2.9 Indirectly Conditioned Spaces

Description: ACMs shall allow users to explicitly model all indirectly conditioned spaces. All Minimum Loads Capabilities found in this manual apply to indirectly conditioned spaces. When indirectly conditioned spaces are explicitly modeled, **ACMs must require the user to identifying each zone as either directly or indirectly conditioned.**

At the user's choice, ACMs may model indirectly conditioned spaces as part of the directly conditioned space provided that the total volume and area of indirectly conditioned spaces included are each less than 15% of the total volume and less than 15% of the total conditioned floor area of the total indirectly and directly conditioned volume and floor area. (Refer to Chapter 4 for requirements applying to indirectly conditioned spaces included as directly conditioned spaces.) For the purposes of this manual, indirectly conditioned spaces can either be occupied or unoccupied. Descriptions of each of these space types are provided in Chapter 4. The requirements for each of these three cases are documented below.

2.2.2.9.1 Indirectly Conditioned Spaces Included in Directly Conditioned Space

Description: The requirements for modeling indirectly conditioned spaces when they are included in directly conditioned space are as described below.

DOE Keyword: SPACE
AREA
VOLUME
MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: Any indirectly conditioned space modeled as part of directly conditioned space shall be input as it occurs in the construction documents, including envelope, occupancy characteristics and lighting levels. Additionally, ACMs must assume mechanical heating and cooling is provided to the space, using the same system as the actual directly conditioned space.

Modeling Rules for Reference Design (All): ACMs must use the same configuration and occupancy characteristics for indirectly conditioned spaces modeled as directly conditioned space as the proposed design. Standard design assumptions for envelope performance, occupancy characteristics, lighting levels, and HVAC system assumptions shall be determined as if the space were directly conditioned.

2.2.2.9.2 Indirectly Conditioned Spaces that can be Occupied and Explicitly Modeled

Description: The requirements for modeling indirectly conditioned spaces that can be occupied and explicitly modeled are as described below.

DOE Keyword: SPACE
AREA
VOLUME
MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For the proposed design ACMs shall receive input for indirectly conditioned spaces for area, configuration, and envelope as each space occurs in the construction documents. All internal loads, receptacle, occupant, process loads shall be determined identically to directly conditioned space.

The reference method will treat the space as a conditioned zone [ZONE-TYPE = CONDITIONED] with heating and cooling off [HEATING-SCHEDULE & COOLING-SCHEDULE set to off] and fans on so that mechanical ventilation will be modeled according to Table 2-1 or 2-2.

Modeling Rules for Reference Design (All): ACMs must use the same configuration and modeling assumptions for indirectly conditioned spaces that can be occupied as the proposed design. Standard design assumptions for envelope performance shall be determined as if the space were directly conditioned.

The reference method will not model mechanical heating or cooling for these spaces, however mechanical ventilation (CFM/sf) will be modeled according to Table 2-1 or 2-2. Lighting levels shall be established identical to directly conditioned space standard design.

2.2.2.9.3 Indirectly Conditioned Spaces that cannot be Occupied and Explicitly Modeled

Description: The requirements for modeling indirectly conditioned spaces that cannot be occupied and explicitly modeled are as described below.

DOE Keyword: SPACE
AREA
VOLUME
MULTIPLIER

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For the proposed design, all ACMs shall receive input for indirectly conditioned spaces for area, configuration, and envelope as each space occurs in the construction documents. All internal loads, ventilation, receptacle, lighting, occupant and process loads shall be zero.

No mechanical heating, cooling or ventilation shall be modeled for indirectly conditioned spaces that cannot be occupied. As in the standard design, for these spaces the reference method models lightweight mass by using a light furniture category of 30 pounds per square foot in DOE 2.1 to generate the lightweight standard weighting factors for these spaces. This lightweight mass is meant to approximate the materials found in conditioned spaces that cannot be occupied.

Modeling Rules for Reference Design (All): ACMs must use the same configuration and modeling assumptions for indirectly conditioned spaces that cannot be occupied as the proposed design. Standard design assumptions for envelope performance shall be determined as if the space were directly conditioned.

For these spaces the reference method models lightweight mass by using a light furniture category of 30 pounds per square foot in DOE 2.1 to generate the lightweight standard weighting factors for these spaces. This lightweight mass is meant to approximate the materials found in indirectly conditioned spaces that cannot be occupied.

The reference method will not model mechanical heating, cooling or ventilation for indirectly conditioned spaces that cannot be occupied.

2.2.2.10 Enclosed Unconditioned and Semi-Conditioned Spaces

Description: ACMs shall require the user to explicitly model any enclosed unconditioned and semi-conditioned spaces such as stairways, warehouses, unoccupied adjacent tenant spaces, attached sunspaces, attics and crawl spaces *if and only if* they are part of the permitted space. ACMs must require the user to identify the space as **unconditioned** and to enter all applicable envelope information, in a similar manner to a conditioned space. **In this manual, the word "unconditioned" is used to refer to both unconditioned and semi-conditioned spaces.**

If the enclosed unconditioned space is not a part of the permitted space, ACMs *may* allow the user to either explicitly model the space or ignore it by modeling the partition separating the condition space from the enclosed unconditioned space as an adiabatic demising partition (see Section 2.2.2.5).

DOE Keyword: SPACE
AREA
VOLUME
MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: If enclosed unconditioned spaces are explicitly modeled, ACMs shall model the envelope characteristics of the unconditioned spaces as input by the user, according to the plans and specifications for the building.

All internal gains and operational loads (occupants, water heating, receptacle, lighting and process loads, ventilation) in unconditioned spaces shall be equal to zero. Infiltration shall be equal to 0.038 times the total wall area exposed to ambient outdoor air.

If enclosed unconditioned spaces are not modeled, the reference program shall model the partitions separating condition spaces from enclosed unconditioned spaces as adiabatic demising partitions.

Modeling Rules for Reference Design (All): ACMs shall model unconditioned spaces exactly the same as the proposed design.

2.2.2.11 Concrete Slab Floors on Grade

Description: Slab-on-grade floor construction typically consisting of 3-1/2 inch thick poured concrete on grade.

DOE Keyword:
UNDERGROUND-FLOOR
WIDTH
HEIGHT
MULTIPLIER

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference method shall model concrete slab floors on grade with a construction consisting of concrete whose thickness must be input by the user and one foot of earth. ACMs shall model an effective ~~U-value~~U-factor of (0) for slab-on-grade floors.

The reference method assumes soil layers to have a thermal conductivity of 0.50 Btu-ft/h-ft^2-^{o}F and a density of 85 lb/ft^3. Concrete is assumed to have a thermal conductivity of 0.7576 Btu-ft/h-ft^2-^{o}F and a density of 140 lb/ft^3. The reference method assumes that both soil and concrete have a specific heat of 0.20 Btu/lb-^{o}F.

Modeling Rules for Reference Design (All): ACMs shall use the same slab floor constructions and areas as the proposed design.

2.2.2.12 Exterior Doors

Description: Doors in exterior partitions.

DOE Keyword:
DOOR
WIDTH
HEIGHT
SETBACK
MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall receive inputs for each exterior door, including construction, thermal characteristics, orientation and tilt, location and area for all doors as they occur in the construction documents.

Modeling Rules for Reference Design (All): The reference method shall model the standard design with the same constructions, orientation and tilt, locations and areas as the proposed design.

2.2.2.13 Light Mass

Description: The heat capacity of interior walls and furniture are modeled as lightweight mass.

DOE Keyword: FURNITURE-TYPE
FURN-WEIGHT
FURN-FRACTION

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall model lightweight mass with constructions specified below. **ACMs shall not have direct user inputs for interior light weight mass.** The reference method determines lightweight mass exclusively as a function of floor area using DOE-2 furniture inputs as described below.

The reference method assumes that lightweight mass is determined from the floor area of the modeled spaces. In the reference method, lightweight mass is modeled through the use of the DOE 2.1 furniture inputs. For directly conditioned spaces and indirectly conditioned spaces that can be occupied the internal mass category is deemed to be [FURNITURE-TYPE = HEAVY]; the average weight of the light mass (furniture and equipment) is assumed to be 80 pounds per square foot [FURN-WEIGHT = 80]; and 85% of the floor is covered by lightweight (furniture) mass [FURN-FRACTION = 0.85]. This furniture fraction determines the fraction of solar gains going to the furniture/light mass. Thus the reference method assigns 85% of the total solar heat gain normally falling on the floor to the furniture instead.

For indirectly conditioned spaces that cannot be occupied the internal mass category is deemed to be [FURNITURE-TYPE = LIGHT]; the average weight of the light mass (furniture and equipment) is assumed to be 30 pounds per square foot [FURN-WEIGHT = 30]; and 85% of the floor is covered by lightweight (furniture) mass [FURN-FRACTION = 0.85].

Modeling Rules for Reference Design (All): The standard design shall model the same lightweight mass as the proposed design.

2.2.2.14 Fenestration products

Description: Any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, French doors, skylights, curtain walls, and garden windows.

Windows include not only common windows but also all fenestration products in the walls of the building envelope. Examples of such fenestration products include all windows and glazing materials, glass block walls, translucent panels, and glass doors. Walls are portions of the building envelope with tilts from vertical to less than 30 degrees from vertical.

DOE Keyword: WINDOW

Input Type: Required

2.2.2.14.1 Fenestration Orientation and Tilt

Description: The reference method models the actual azimuth (direction) and surface tilt of windows and skylights (fenestration products) in each wall and roof surface.

DOE Keyword: Same as EXTERIOR-WALL

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: Azimuth and surface tilt of each glazing surface shall be input as they occur in the construction documents.

Modeling Rules for Reference Design (All): Azimuth and surface tilt of each glazing surface shall be the same as they occur in the proposed design.

2.2.2.14.2 Fenestration Thermal Properties

Description: ACMs shall model the overall ~~U-value~~U-factor and Solar Heat Gain Coefficient (SHGC) for each fenestration assembly, including inside and outside air films and effects of framing, spacers and other non-glass materials as applied to the full rough-out fenestration area. For manufactured fenestration assemblies, the overall ~~U-value~~U-factor and SHGC are from the NFRC label attached to the assembly or from default values listed in Tables 1-D and 1-E of the Standards.

For ~~each~~ site assembled vertical glazing ~~field-fabricated fenestration assembly assemblies~~ in buildings with 100,000 square feet of conditioned floor area or greater and 10,000 square feet of vertical glazing or greater, ACMs must allow the user to *either* input the default U-~~value~~ factor and SHGC listed in Tables 1-D and 1-E or use NFRC U-factor ratings for site built fenestration~~field-fabricated systems~~. For buildings under 100,000 square feet of conditioned floor area or with less than 10,000 square feet of vertical glazing, the user can either use NFRC ratings for site built fenestration ~~of the Standards~~, default values from Tables 1-D and 1-E, *or* determine the U-factor from default values in Appendix I and calculate the assembly's ~~U-value and~~ SHGC using ~~a~~ the method shown in Appendix I~~approved by the Commission~~. For skylights that do not have U-factor and SHGC values certified to NFRC, the values shall be determined from Appendix I.

In this Section the word "Window" is used to refer to fenestration. A horizontal window with a tilt of up to 60 degrees from the horizontal is a skylight.

DOE Keyword: FRAME-CONDUCTANCE
FRAME-WIDTH
FRAME-ABS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: For manufactured windows, ACMs must require the user to input the ~~U-value~~U-factor and SHGC for each window from the NFRC label as it occurs in the construction documents for the building.

For site assembled vertical glazing ~~field-fabricated windows~~ in buildings with 100,000 square feet of conditioned floor area or greater and 10,000 square feet of vertical glazing or greater, ACMs must either use the default U-~~value~~ factor and SHGC listed in Tables 1-D and 1-E of the Standards *or* ~~calculate the overall U-value and SHGC using a method approved by the Commission.~~use NFRC ratings for ~~field fabricated systems~~ site built fenestration.

For site assembled vertical glazing ~~field-fabricated windows~~in buildings under 100,000 square feet of conditioned floor area or with less than 10,000 square feet of vertical glazing, ACMs must determine the U-factor and SHGC using procedures and defaults specified in Appendix I, or use NFRC ratings for site built fenestration~~field fabricated systems; or calculate the overall U-value and SHGC using a method approved by the Commission.~~

For skylights, ACMs must determine the U-factor and SHGC using procedures and defaults specified in Appendix I, or use NFRC ratings for ~~field fabricated systems~~ site built fenestration~~; or calculate the overall U-value and SHGC using a method approved by the Commission.~~ The reference program uses a FRAME ABSORPTANCE of 0.70.

Modeling Rules for Reference Design (New & Altered Existing): ACMs shall use the appropriate "Maximum ~~U-value~~U-factor" and RSHG or SHGC for the window as appropriate from Tables 1-H and 1-I of the Standards including the framing according to the occupancy type and the climate zone. The reference design uses a FRAME ABSORPTANCE of 0.70.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the existing design's ~~U-value~~U-factor and SHGC or RSHG as appropriate including the framing. The reference design uses a FRAME ABSORPTANCE of 0.70.

2.2.2.14.3 Area of Fenestration in Walls & Doors

Description: Fenestration surfaces include all glazing in walls and vertical doors of the building. The following inputs must be received.

Fenestration dimensions. For each glazing surface, all ACMs must receive an input for the glazing width and height. The glazing dimensions are those of the rough-out opening for the window(s) or fenestration product. The area of the fenestration product will be the width times the height. For fenestration products with glazing surfaces on more than a single side such as garden windows, the ACM must be able to accept entry for the dimensions of each side (glazing plus frame) with conditioned space on one side and unconditioned space on the other.

Display Perimeter. In a secondary menu (subordinate to the menu for fenestration area entries), the ACM must allow the user to specify a value for the length of display perimeter, in feet, for each floor or story of the building. **The user entry for Display Perimeter must have a default value of (0) zero. Note: Any non-zero input for Display Perimeter is an exceptional condition that must be reported on the PERF-1 exceptional condition list and must be reported on the ENV forms.** The value for Display Perimeter is used as an alternate means of establishing Maximum Wall Fenestration Area in the standard design (Title 24, § 143). As defined in Section 101(b) of the Standards, display perimeter is:

... the length of an exterior wall in a B-2 occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.

Floor Number. The ACM must also allow the user to specify the Display Perimeter associated with each floor (story) of the building.

DOE Keyword: WIDTH
HEIGHT

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall receive inputs for the proposed design fenestration width and height as they are documented on the construction documents.

Modeling Rules for Reference Design (New & Altered Existing): The reference method calculates the maximum allowed fenestration area. This *Maximum Wall Fenestration Area* is 40% of the gross exterior wall area of the building that is conditioned when display perimeter is not specified.

If Display Perimeter is specified, the *Maximum Wall Fenestration Area* is either 40% of the gross exterior wall area of the building, or six feet times the Display Perimeter for the building, whichever value is greater.

The reference method automatically calculates these two maximum fenestration areas for fenestration in walls and uses the greater of the two for the total glazing area of the reference building.

1. When the Window Wall Ratio in the proposed design is ≤ 0.40 or $\leq$ display perimeter $\times$ 6 feet, the standard design shall use the same wall fenestration height and width for each glazing surface of the proposed design exterior wall.

2. When the proposed design area of fenestration in walls and doors is greater than the maximum wall fenestration area described above, ACMs shall adjust the height and width of each glazing surface by multiplying them by a fraction equal to the square root of :

Maximum Allowed Wall Fenestration Area/Total Proposed Fenestration Area.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the same fenestration area as the existing design.

2.2.2.14.4 Window-to-Wall Ratio

Description: Ratio of the total window area to the gross exterior wall area.

DOE Keyword: N/A

Input Type: Calculated based on the dimensions of exterior walls and windows.

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall calculate the window-to-wall ratio based on inputs for width and height of exterior walls and windows as they occur in the construction documents.

Modeling Rules for Reference Design (New & Altered Existing): For the standard design the area of each exterior wall construction shall equal the area of each exterior wall of the proposed design, except when the wall area of the proposed design exceeds the maximum allowable window-to-wall ratio (WWR). There are three cases, when the proposed design glazing exceeds the maximum allowable window-to-wall ratio (WWR), which must be accounted for:

(1) *One Wall Construction*. If the window occurs in a portion of wall where it abuts only one construction, the ACM must decrease the glazing area to the allowable maximum and increase the area of the wall accordingly.

(2) *Multiple Wall Constructions.* If the window occurs in a portion of wall where it abuts more than one construction in a given orientation, the ACM must increase the area of each adjacent wall construction by the same proportion, as glazing area decreases.

(3) *Propose WWR = 1.0*. If the Window-to-Wall Ratio, WWR, for any orientation or exterior surface is 1.0, the ACM must calculate the area weighted average (AWA) HC for all of the walls of the proposed design to determine an HC for the hypothetical wall. The glazing amount is reduced and a wall is inserted as follows:

(a) AWA HC < 7.0 Btu/ft^2-^{o}F: The standard assembly is a steel-framed, lightweight wall with HC = AWA HC of the proposed walls and with a ~~U-value~~U-factor matching the requirement listed in Table 1-H or 1-I of the Standards for other walls with HC < 7.0 and the applicable climate zone.

(b) AWA HC ≥7.0 Btu/ft^2-^{o}F: The standard assembly is a homogeneous material with a ~~U-value~~U-factor matching the applicable value listed in

Table 1-H or 1-I of the Standards for the applicable HC range and climate zone and the same HC as the proposed AWA HC.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the same window-to-wall ratio as the existing design.

2.2.2.14.5 Solar Heat Gain Coefficient of Fenestration in Walls & Doors

Description: The reference method models the solar heat gain coefficient (SHGC) of glass including the framing, dividers, and mullions. The shading effects of dirt, dust, and degradation are purposely neglected and an ACM user may not adjust solar heat gain coefficients because of these effects. The ACM user's manual must reflect these restrictions on user entries.

If the user has specified Display Perimeter, ACMs may also receive an input in a subordinate menu for the Relative Solar Heat Gain (RSHG) requirement except for cases where local building codes prohibit or limit the use of overhangs or exterior shading devices. The use of this RSHG exception input is itself an exceptional condition that must be reported in the exceptional conditions checklist of the PERF-1 form.

DOE Keyword: SHADING-COEF

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Fenestration solar heat gain coefficient (SHGC) for each fenestration surface shall be input as it occurs in the construction documents for the building. ACMs that require inputting shading coefficient (SC) instead of SHGC shall calculate the fenestration's shading coefficient using the following formula:

$$SC_{fenestration} = SHGC/0.87$$

Note: This equation is taken from Blueprint #57, dated Fall 1996. Since both SC for nonresidential buildings and SHGC apply to the entire rough-out opening, the adjustment for framing and divider has been removed.

Modeling Rules for Reference Design (New & Altered Existing): ACMs shall use the appropriate maximum RSHG values from Tables 1-H and 1-I of the Standards according to occupancy, climate zone, window wall ratio and orientation as the standard design solar heat gain coefficient. The maximum RSHG is different for north-oriented glass; for the purposes of establishing standard design solar heat gain coefficient, north glass is glass in walls facing from 45^{o} west (not inclusive) to 45^{o} east (inclusive) of true north.

If the user has claimed the RSHG exception for a section of display perimeter, the standard design uses the maximum RSHG for north glass found in Tables 1-H and 1-I of the Standards for any fenestration surface utilizing this exception.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the same RSHG value as the existing design including the framing.

2.2.2.14.6 Area of Fenestration in Exterior Roofs

Description: ACMs must model the exposed surface area of fenestration in roofs separating those with transparent and translucent glazing. Such fenestration surfaces include all skylights or windows in the roofs including operable skylights and windows in the roofs of the building.

DOE Keyword: WIDTH
HEIGHT

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall receive inputs for width, length and height of each fenestration surface of the proposed design as they are shown in the construction documents.

Modeling Rules for Reference Design (New & Altered Existing): ACMs must calculate the maximum allowed area of fenestration in roofs. This *Maximum Roof Fenestration Area* is 5% of the gross exterior roof area of the entire permitted space or building.

1. When the Skylight Roof Ratio (SRR) in the proposed design is ≤ 0.05, for each roof fenestration, the standard design shall use the same dimensions as the proposed design.

2. When the Skylight Roof Ratio in the proposed design is > 0.05, the ACM shall adjust the dimensions of each roof fenestration of the standard design by multiplying them by a fraction equal to the square root of :

$$SRR_{standard}/SRR_{proposed}$$

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the same fenestration area as the existing design.

2.2.2.14.7 Solar Heat Gain Coefficient of Fenestration in Roofs

Description: The reference method models the solar heat gain coefficient of the fenestration including the glass and framing. The shading effects of dirt, dust, and degradation are purposely neglected and an ACM user may not adjust solar heat gain coefficients because of these effects. The ACM user's manual must reflect these restrictions on user entries.

DOE Keyword: SHADING-COEF

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Fenestration solar heat gain coefficient for each fenestration surface in the roof(s) of a building or permitted space shall be input as it occurs in the construction documents for the building or permitted space. ACMs that require inputting shading coefficient (SC) instead of SHGC shall calculate the fenestration's shading coefficient using the following formula:

$$SC_{fenestration} = SHGC/0.87$$

Note: This equation is taken from Blueprint #57, dated Fall 1996. Since both SC for nonresidential buildings and SHGC apply to the entire rough-out opening, the adjustment for framing and divider has been removed.

Modeling Rules for Reference Design (New & Altered Existing): ACMs shall use the appropriate maximum solar heat gain coefficient from Tables 1-H and 1-I of the Standards according to the occupancy type, the climate zone and the fenestration type.

Modeling Rules for Reference Design (Existing Unchanged): The standard design shall use the same SHGC value as the existing design.

2.2.2.15 Overhangs

Description: ACMs must be capable of modeling overhangs over windows and must have the following inputs:

Overhang position. The distance from the edge of the window to the edge of the overhang.

Height above window. The distance from the top of the window to the overhang.

Overhang Width. The width of the overhang parallel to the plane of the window.

Overhang extension. The distance the overhang extends past the edge of the window jams.

Overhang Angle. The angle between the plane of window and the plane of the overhang.

DOE Keyword: OVERHANG-A
OVERHANG-B
OVERHANG-W
OVERHANG-D
OVERHANG-ANGLE

Input Type: Default

Tradeoffs:	Yes
Modeling Rules for Proposed Design:	Overhangs shall be modeled in the proposed design for each window as they are shown in the construction documents.
Default:	No overhang
Modeling Rules for Reference Design (New & Altered Existing):	Overhangs shall not be modeled in the standard design; however, the fenestration must meet the prescriptive requirements for ~~U-value~~U-factor and solar heat gain coefficient.
Modeling Rules for Reference Design (Existing Unchanged):	Overhangs shall be modeled in the same manner as they occur in the existing design.

2.2.2.16 Vertical Shading Fins

Description:	ACMs must be capable of modeling vertical fins. Vertical fins shall affect the solar gain of fenestration products only. ACMs must have the following inputs: *Wall/window*. Input must require the user to specify the wall/or window with which the fin is associated. *Horizontal position*. The distance from the outside edge of the window to the fin. *Vertical position*. The distance from the top edge of the fin to the top edge of the window. *Fin height*. The vertical height of the fin. *Depth*. The depth of the fin, measured perpendicularly from the wall to the outside edge of the fin.
DOE Keyword:	LEFT-FIN-A RIGHT-FIN-A LEFT-FIN-B RIGHT-FIN-B LEFT-FIN-H RIGHT-FIN-H LEFT-FIN-D RIGHT-FIN-D
Input Type:	Default
Tradeoffs:	Yes
Modeling Rules for Proposed Design:	Vertical fins shall be modeled in the proposed design for each window as they are shown in the construction documents.
Default:	No vertical fins
Modeling Rules for Reference Design (New	Vertical fins shall not be modeled in the standard design; however, the fenestration must meet the prescriptive requirements for ~~U-value~~U-factor and

& Altered Existing): solar heat gain coefficient.

Modeling Rules for Reference Design (Existing Unchanged): Vertical fins shall be modeled in the same manner as they occur in the existing design.

2.2.2.17 Exterior Fenestration Shading Devices

Description: ACMs must be able to model exterior fenestration shading devices which affect the solar gain of glazing surfaces.

DOE Keyword: N/A

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: Exterior fenestration shading devices shall be modeled in the proposed design for each window as they are shown in the construction documents.

Note: Applications of Exterior Shading Devices are very limited; see Section 4.3.2.24 for restrictions on modeling Exterior Shading Devices.

Default: No exterior fenestration shading devices

Modeling Rules for Reference Design (New & Altered Existing): Exterior fenestration shading devices shall not be modeled in the standard design; however, the fenestration must meet the prescriptive requirements for ~~U-value~~U-factor and solar heat gain coefficient.

Modeling Rules for Reference Design (Existing Unchanged): Exterior fenestration shading devices shall be modeled in the same manner as they occur in the existing design.

2.2.2.18 Window Management

Description: The reference method simulates window management/interior shading devices in the following manner. ACMs may either use this method or a method yielding equivalent results.

Window solar heat gain coefficient is multiplied by a multiplier which gives the effective solar heat gain coefficient for combined shading device and window when the shading device covers the window.

DOE Keyword: SHADING-SCHEDULE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The proposed design shall model fixed interior drapes with a solar heat gain coefficient multiplier of 0.80.

Modeling Rules for Reference Design (All): The standard design models the same window management as the proposed design.

2.2.3 Below-Grade Envelope

2.2.3.1 Underground Walls

Description: Underground walls separate a conditioned space from the adjacent soil or bedrock.

DOE Keyword: UNDERGROUND-WALL
WIDTH
HEIGHT

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference method shall model below grade walls using UNDERGROUND-WALL Keyword using their actual construction, input by the user, with an additional one-foot layer of earth coupled to the ground temperature. ACMs must set the effective ~~U-value~~U-factor of underground walls to zero

The reference method shall assume soil layers to have a thermal conductivity of 0.50 Btu-ft/h-ft^2-^{o}F and a density of 85 lb/ft^3. Concrete is assumed to have a thermal conductivity of 0.7576 Btu-ft/h-ft^2-^{o}F and a density of 140 lb/ft^3. The reference method assumes that both soil and concrete have a specific heat of 0.20 Btu/lb-^{o}F.

Modeling Rules for Reference Design (All): ACMs shall model underground walls in the standard design exactly the same as they are modeled in the proposed design, including construction, area and position.

2.2.3.2 Underground Concrete Floors

Description: Underground concrete floors separate a conditioned space from the adjacent soil or bedrock.

DOE Keyword: UNDERGROUND-FLOOR
WIDTH
HEIGHT

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall model underground floor constructions and areas input as they occur in the construction documents along with a one-foot layer of soil beneath the floor. ACMs must set the effective ~~U-value~~U-factor of underground floors to zero.

The reference method shall assume soil layers to have a thermal conductivity of 0.50 Btu-ft/h-ft^2-°F and a density of 85 lb/ft^3. Concrete is assumed to have a thermal conductivity of 0.7576 Btu-ft/h-ft^2-°F and a density of 140 lb/ft^3. The reference method assumes that both soil and concrete have a specific heat of 0.20 Btu/lb-°F.

Modeling Rules for Reference Design (All): The standard design shall use the same underground floor constructions, areas, and position as the proposed design.

2.3 Building Occupancy - Required Capabilities

The user of an ACM must be able to select an occupancy type from certain allowed tables. ACMs that do not have separate selection lists for ventilation occupancy assumptions and all other occupancy assumptions must allow the user to select from the occupancies listed in Table 2-1 and Table 2-2 or to select from an officially approved alternative sub-occupancy list that maps into those occupancies. ACMs that have separate occupancy selection lists for ventilation assumptions and other assumptions must use the occupancy selections given in tables in the building energy efficiency standards or approved alternative lists of occupancies. The occupancies listed in Table 1-F in the standards must be used for ventilation occupancy selections and the occupancies listed in Table 1-N in the standards must be used for selecting the remaining occupancy assumptions. Alternatively specific occupancy selection lists approved by the Commission that map into Tables 1-F or 1-N may be used.

A building consists of one or more occupancy types. ACMs cannot combine different occupancy types. Tables 2-1 and 2-2 describe all of the schedules and full load assumptions for occupants, lighting, infiltration, receptacle loads and ventilation. Full load assumptions are used for both the proposed design and the reference design compliance simulations.

2.3.1 Occupancy Assignment

2.3.1.1 Occupancy Types

Description: A modeled building must have at least one defined occupancy type. A default occupancy of "unknown" may be used to fulfill this requirement. Alternative Calculation Methods (ACMs) must model the following *occupancy* types for buildings and spaces when lighting compliance is not performed or lighting plans are submitted for the entire building. Occupancies that are considered as subcategories of these occupancies are listed below each occupancy. These occupancy types are also listed in Table 2-1 of this manual:

- Commercial and Industrial Work
  including both general and precision work, barber and beauty

shops, laundries, and dry cleaning
- Grocery Store
  including convenience stores
- Industrial and Commercial Storage
- Medical/Clinical
- Office
  including banks & financial institutions, courtrooms, accounting, art, design drafting and engineering spaces
- Other
  including corridors, restrooms, and support areas as well as ALL others not specifically mentioned herein for spaces without lighting plans
- Religious Worship, Auditorium, Convention Center
  including exhibit display areas and lobbies associated with religious worship spaces, auditoriums, and convention centers
- Restaurant
  including dining rooms, kitchens, hotel function areas, bars, cocktail lounges, casinos
- Retail and Wholesale Store
- School
  including classrooms, day care, kindergarten, primary and secondary schools, trade schools, training centers, colleges, universities, research areas, laboratories
- Theater
  including movie theaters, live stage performance theaters, malls, arcades, and atria
- Unknown

Again, ACMs with default occupancies must use the "unknown" occupancy category as a default.

When lighting plans are submitted for portions or for the entire building or when lighting compliance is not performed, Alternative Calculation Methods (ACMs) must model the following *area occupancy* types for spaces within an HVAC zone. These *area occupancy* types are listed in Table 2-2 of this manual. (Note: Some additional *area occupancies* are listed as subcategories of the *area occupancies* listed in Table 2-2):

- Auditorium
- Auto Repair Workshop
- Bank/Financial Institution
  including Banks, Savings & Loans, Credit Unions, Mortgage and Title Insurance
- Bar, Cocktail Lounge and Casino including cabarets, night clubs, bingo parlors and other gaming rooms with smoking
- Beauty Shop
- Barber Shop
- Classroom
  including areas for instructional purposes
- Commercial/Industrial Storage
  including warehouses and storage and stock rooms
- Commercial/Industrial Work - General, High Bay
  including manufacturing areas
- Commercial/Industrial Work - General, Low Bay

including manufacturing areas

- Commercial/Industrial Work - Precision
  Note: the use of this category is an exceptional condition and must be documented on the exceptional conditions checklist.
- Convention, Conference and Meeting Center
- Corridor, Restroom and Support Area
  including all circulation spaces, elevators, escalators, stairways, and janitorial room
- Courtrooms
- Dining Area
  including cafeterias and ballrooms
- Dry Cleaning (Coin Operated)
- Dry Cleaning (Full Service Commercial)
- Electrical, Mechanical Rooms
- Exercising Rooms and Gymnasium
  including day care, health clubs, sports arena, exercise rooms, dojos, spas, pools, saunas, and massage rooms
- Exhibit Display Area and Museum
  including art galleries
- Grocery Sales Area
- High-Rise Residential
- Hotel Function Area
- Hotel/Motel Guest Room
- Kitchen and Food Preparation
- Laundry
- Library - Reading Area
- Library - Stacks
- Lobby - Hotel
- Lobby - Main Entry
  including depots, terminals, and stations
- Lobby - Office Reception/Waiting
- Locker/Dressing Room
- Lounge/Recreation
- Mall, Arcade and Atrium
- Medical and Clinical Care
  including dental care, optical care
- Mixed Occupancy
- Office
  including accounting, counseling, art, drafting, design, insurance, stock & bond brokers, filing areas, conference rooms, mail rooms, telecommunications, and computer areas
- Other
- Religious Worship
  including churches, synagogues, temples, tabernacles, mosques, basilicas, cathedrals, missions, chapels, meditation areas, altars, shrines, worship centers, funeral homes, and memorials
- Retail Sales, Wholesale Showroom
  including pharmacies, drug stores, floral shops, video tape rentals
- Smoking Lounge
- Theater (Motion Picture)
- Theater (Performance)
  including dance halls and discotheques

- Unknown

Please note that this list is comprehensive given the categories "other" and "unknown." *Occupancies* and *area occupancies* other than those listed herein cannot be approximated by another *occupancy* or *area occupancy* unless that substitution has been approved by the Executive Director of the Commission in writing.

The selection lists accommodate unknown or miscellaneous unlisted occupancies. Any known occupancy not reasonably similar (as determined by the local building official) to an occupancy specified on a Commission-approved list is considered "other." Occupancies unknown to the applicant must use the occupancy type "unknown."

DOE Keyword: SPACE-CONDITIONS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must require users to specify the *occupancy* of the building or the *area occupancy* of each zone being modeled. ACMs must require the user to identify if lighting compliance is performed (lighting plans are included or have already been submitted). ACMs shall determine the occupancy type as follows:

Lighting compliance not performed. The ACM must require the user to select the *occupancy* type(s) for the building from the occupancies reported in Table 2-1 or Table 1-M of the Standards. **The ACM must use the occupancy assumptions of this Table for compliance simulations**.

Lighting compliance performed. The ACM must require the user to select the *occupancy* type(s) for each zone from the occupancies reported in Table 2-2 or Table 1-N of the Standards. **The ACM must use the *area occupancy* assumptions from Table 2-2 for compliance simulations**.

Tailored lighting and tailored ventilation are permitted as exceptional condition modifications to these default assumptions, but must be reported on the PERF-1 as exceptional conditions and on other applicable compliance forms. The tailored lighting values cannot be traded off for other features.

ACMs must use the same default assumptions, listed in Tables 2-1 through 2-6 of this manual including schedules, occupant densities, outside air ventilation rates, lighting loads, receptacle loads and service water heating loads. ACMs may have a separate occupancy list for ventilation versus other assumptions subject to the constraint that occupancy schedule types cannot be mixed. Users must select occupancy of a given space based upon the proposed or anticipated occupancy not on the amount of lighting desired. ACM input must emphasize occupancy choices and similarities not lighting choices. ACMs may not report the occupancy default lighting watts per square foot on the screen when the user is selecting occupancies for a space. After the occupancies are selected by the user, the lighting determined from the user's occupancy selection may appear on a separate entry screen as a default entry in the lighting power input if the user has not already entered it.

Modeling Rules for Reference Design (All): ACMs must model the same *occupancy* type(s) and *area occupancy* type(s) as the proposed building. ACMs must use the same default assumptions found in Tables 2-1 through 2-6. Tailored lighting and tailored ventilation are permitted as a modification to these default assumptions but must be reported on the PERF-1 exceptional condition list. Refer to sections for *Lighting, Ventilation, and Process Loads* for respective requirements for each of these adjustments.

2.3.1.2 Mixed Area Occupancies

Description: ACMs shall allow the user to select *mixed* as the occupancy type when selecting an area occupancy for each zone. This option shall only be available if lighting compliance is performed (lighting plans are (or have been) submitted for the zone). Refer to Chapter 4 for restrictions on selecting *mixed* as the area occupancy type.

DOE Keyword: SPACE-CONDITIONS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM must request input for the following:

1. Total area of the space

2. Area and occupancy type of up to four different area occupancy types; however, the subareas may also be optionally entered as percentages of the total area.

The ACM must automatically calculate the sum of the areas for the four different occupancies:

- If the sum of the four different areas (or percentages) is greater than the input total area of the space, the ACM must require corrected input or proportionately scale down the entries so that the sum is the total area.

- If the sum of the four different occupancies is less than the input total area, the ACM must assign the occupancy *other* to the area needed to equal the input total area.

The ACM shall assign occupancy-determined assumptions for occupant densities, outside air ventilation rates, lighting loads, receptacle loads and service water heating loads by calculating the area-weighted average for each of these inputs, using the areas input by the user. Refer to sections for *Lighting, Ventilation*, and *Process Loads* for respective requirements for each of these adjustments.

ACMs shall not allow input of area occupancies with different schedules (e.g. Nonresidential and Residential) within the same *mixed* area occupancy. However, "Corridor, Restroom, and Support Area" spaces may be part of a mixed occupancy and use the schedule of the other occupancies making up the mixed occupancy zone rather than the default schedule assigned to this occupancy type.

Modeling Rules for Reference Design (All): ACMs must use the same default assumptions calculated for the proposed design, as well as any tailored lighting, tailored ventilation, and receptacle loads input for the proposed design.

Table 2-1: Occupancy Assumptions When Lighting Plans are Submitted for the <u>Entire</u> Building or When Lighting Compliance is not Performed

Occupancy Type	#people / 1000SF[1]	Sensible / person[2]	Latent / person[2]	Recept. W/SF[3]	Water Btuh / person	Lighting W/SF[4]	CFM / SF[5]
Commercial and Industrial Storage	5	268	403	0.43	108	0.7	0.15
Grocery Store	29	252	225	0.91	113	1.5	0.23
General Commercial and Industrial Work, High Bay	7	375	625	1.0	120	1.2	0.15
General Commercial and Industrial Work, Low Bay	7	375	625	1.0	120	1.0	0.15
Medical/Clinical	10	250	213	1.18	110	1.2	0.15
Office	10	250	206	1.34	106	1.2	0.15
Other	10	250	200	1.0	120	0.6	0.15
Religious Worship, Auditorium~~, Convention~~	136	245	112	0.96	57	1.8	1.03
<u>Convention</u>	<u>136</u>	<u>245</u>	<u>112</u>	<u>0.96</u>	<u>57</u>	<u>1.4</u>	<u>1.03</u>
Restaurant	45	274	334	0.79	366	1.2	0.38
Retail and Wholesale Store	29	252	224	0.94	116	1.7	0.23
School	40	246	171	1.0	108	1.4	0.32
Theater	130	268	403	0.54	60	1.3	0.98
Unknown	10	250	200	1.0	120	1.2	0.15

(1) Most occupancy values are based on an assumed mix of suboccupancies within the area. These values were taken from the 1994 Uniform Building Code, Table No. 10-A. Full value for design conditions. Full year operational schedules reduce these values by up to 50% for compliance simulations and full year test simulations.

(2) From Table 3, p. 28.8, ASHRAE 1997 Handbook of Fundamentals

(3) From Lawrence Berkeley Laboratory study. This value is fixed and includes all equipment that are plugged into receptacle outlets.

(4) From Table 1-M of the Standards for the applicable occupancy.

(5) Developed from Section 121 and Table 1-F of the Standards.

Table 2-2: Area Occupancy Assumptions When Lighting Plans are Submitted for <u>Portions</u> or for the <u>Entire</u> Building or When Lighting Compliance is not Performed

Sub-Occupancy Type (1)	#people 1000 SF(2)	Sensible person(3)	Latent person(3)	Recept. W/SF(4)	Water Btuh person	Lighting W/SF(5)	CFM SF(6)
All Others	10	250	200	1.0	120	0.6	0.15
Auditorium	143	245	105	1.0	60	2.0	1.07
Auto Repair Workshop	10	275	475	1.0	120	1.2	1.50
Bank/Financial Institution	10	250	250	1.5	120	1.4	0.15
Bar, Cocktail Lounge and Casino	67	275	275	1.0	120	1.1	1.50
Barber and Beauty Shop	10	250	200	2.0	120	1.0	0.40
Classroom	50	245	155	1.0	120	1.6	0.38
Courtrooms	25	250	200	1.5	120	1.1	0.19
Commercial/Industrial Storage	3	275	475	0.2	120	0.6	0.15
Commercial/Industrial Work-General, High Bay	10	275	475	1.0	120	1.2	0.15
Commercial/Industrial Work-General, Low Bay	10	275	475	1.0	120	1.0	0.15
Commercial/Industrial Work-Precision (8)	10	250	200	1.0	120	1.5	0.15
Convention, Conference and Meeting Center	67	245	155	1.0	60	~~1.6~~<u>1.5</u>	0.50
Corridor, Restroom, and Support Area	10	250	250	0.2	0	0.6	0.15
Dining Area	67	275	275	0.5	385	1.1	0.50
Dry Cleaning (Coin Operated)	10	250	250	3.0	120	1.0	0.30
Dry Cleaning (Full Service Commercial)	10	250	250	3.0	120	1.0	0.45
Electrical and Mechanical Room	3	250	250	0.2	0	0.7	0.15
Exercising Centers and Gymnasium	20	255	875	0.5	120	1.0	0.15
Exhibit Display Area and Museum	67	250	250	1.5	60	2.0	0.50
Grocery Sales Area	33	250	200	1.0	120	1.6	0.25
High-Rise Residential (9)	5	245	155	0.5	(7)	0.5	0.15
Hotel Function Area	67	250	200	0.5	60	2.2	0.50
Hotel/Motel Guest Room (9)	5	245	155	0.5	2800	0.5	0.15
Kitchen and Food Preparation	5	275	475	1.5	385	1.7	0.15
Laundry	10	250	250	3.0	385	0.9	0.15
Library - Reading Areas	20	250	200	1.5	120	1.2	0.15
Library - Stacks	10	250	200	1.5	120	1.5	0.15
Lobby - Hotel	10	250	250	0.5	120	~~2.2~~<u>1.7</u>	0.15
Lobby - Main Entry and Assembly	143	250	250	0.5	60	1.5	1.07
Lobby - Office Reception/Waiting	10	250	250	0.5	120	1.1	0.15
Locker and Dressing Room	20	255	475	0.5	385	~~0.9~~<u>0.8</u>	0.15
Mall, Arcade and Atrium	33	250	250	0.5	120	1.2	0.25
Medical and Clinical Care	10	250	200	1.5	160	1.4	0.15
Office	10	250	200	1.5	120	1.3	0.15
Police Station and Fire Station	10	250	200	1.5	120	0.9	0.15
Religious Worship	143	245	105	0.5	60	2.1	1.07
Retail Sales and Wholesale Showroom	33	250	200	1.0	120	2.0	0.25
Smoking Lounge	67	275	275	0.5	120	1.1	1.50
Theater (Motion Picture)	143	245	105	0.5	60	0.9	1.07
Theater (Performance)	143	245	105	0.5	60	1.4	1.07
Unknown	10	250	200	1.0	120	0.8	0.15

(1) Subcategories of these suboccupancies are described in Section 2.3.1.1 (Occupancy Types) of this manual.

(2) Values taken from the 1994 Uniform Building Code, Table No. 10-A. Full value for design conditions. Full year operational schedules reduce these values by up to 50% for compliance simulations and full year test simulations.
(3) From Table 3, p. 28.8, ASHRAE 1997 Handbook of Fundamentals.
(4) From Lawrence Berkeley Laboratory study. This value is fixed and includes all equipment that are plugged into receptacle outlets.

Notes for Table 2-2 (continued)

(5) From Table 1-N of the Standards for the applicable occupancy. ACMs must use this value for the standard building design when lighting compliance is performed for the zone or area in question.
(6) Developed from Section 121 and Table 1-F of the Standards.
(7) Refer to residential water heating method.
(8) The use of this occupancy category is an exceptional condition that must appear on the exceptional conditions checklist and thus requires special justification and documentation and independent verification by the local enforcement agency.
(9) For hotel/motel guest rooms and high-rise residential spaces all these values are fixed and are the same for both the proposed design and the standard design. ACMs must ignore user inputs that modify these assumptions for these two occupancies.

2.3.1.3 Occupant Loads

Description: Based on the occupancy or area occupancy type(s) input by the user, ACMs shall determine the correct occupant density and sensible and latent heat gain per occupant.

DOE Keyword: PEOPLE-SCHEDULE
AREA/PERSON
PEOPLE-HG-SENS
PEOPLE-HG-LAT

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall determine the correct occupant load and sensible and latent heat gain per occupant from Table 2-1 or Table 2-2.

Modeling Rules for Reference Design (All): The standard design shall use the same occupant density and sensible and latent heat gain per occupant as the proposed design.

2.3.1.4 Receptacle Loads

Description: Based on the occupancy or area occupancy type(s) input by the user, ACMs shall determine the correct receptacle load for each occupancy type.

The receptacle load includes all equipment that are plugged into receptacle outlets. For an office occupancy the receptacle load includes all plugged-in office equipment including computer CPUs, computer monitors, workstations, and printers.

DOE Keyword: EQUIPMENT-W/SQFT
EQUIP-SCHEDULE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall determine the correct receptacle load from Table 2-1 or Table 2-2.

Modeling Rules for Reference Design (All): The standard design shall use the receptacle load of the proposed design.

2.3.1.5 Process Loads

Description: Process load is the internal energy of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy. Process load may include sensible and/or latent components.

ACMs shall model and simulate process loads only if the amount of the process energy and the location and type of process equipment are specified in the construction documents. These information must correspond to specific special equipment shown on the building plans and detailed in the specifications. The ACM Compliance Documentation shall inform the user that the ACM will output process loads including the types of process equipment and locations on the compliance forms.

ACMs shall use the Equipment Schedules from Tables 2-4, 2-5, 2-6, or 2-7 for the operation of process equipment based on the occupancy type selected by the user.

DOE Keyword: SOURCE-TYPE
SOURCE-BTU/HR
SOURCE-SENSIBLE
SOURCE-LATENT

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must receive input for Sensible and/or Latent Process Load for each zone in the proposed design. The process load input must include the amount of the process load (W/ft^2), the type of process equipment, and the HVAC zone where the process equipment is located. The modeled information must be consistent with the plans and specifications of the building.

Default: No Process Loads

Modeling Rules for Reference Design (All): The standard design shall use the same process loads for each zone as the proposed design.

2.3.1.6 Infiltration

Description: ACMs shall model infiltration of outdoor air through exterior surfaces.

DOE Keyword: INF-SCHEDULE
INF-METHOD
AIR-CHANGES/HR

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: Infiltration shall either be modeled as "ON" or "OFF", for each zone, according to the following:

- "OFF" if fans are ON and zone supply air quantity (including transfer air) is greater than zone exhaust air quantity.
- "ON" if fans are OFF.

When infiltration is "ON", the reference method calculates the infiltration rate as 0.038 cfm per square foot of gross exterior partition (walls and windows) area for the zone.

Modeling Rules for Reference Design (All): ACMs shall model infiltration for the standard design exactly the same as the proposed design.

2.3.2 Occupancy Lighting

2.3.2.1 Lighting

Description: ACMs shall model Lighting Power Density or LPD (in watts per square foot) for each space. Lighting loads shall be included as internal heating loads. ACMs must allocates 100% of the lighting heat to the space in which the lights occur.

ACMs shall receive an input to indicate one of the following conditions for the building:

1. *Lighting compliance not performed*. When the user indicates with the required ACM input that no lighting compliance will be performed, the ACM must require the user to select and input the occupancy type(s) of the building from Table 2-1 or 2-2. The ACM shall determine the lighting levels based on the selected occupancy type(s). An ACM must not allow the user to input any lighting power densities for the building.

   Note: ACMs may use Table 2-1 even if the building has multiple occupancies.

2. *Lighting compliance performed*. When the user indicates with the required ACM input that lighting compliance will be performed and lighting plans will be submitted for the entire building (excluding the residential units of high-rise residential buildings and hotel/motel guest rooms), the ACM must require the user to select and input the occupancy type(s) from Table 2-1 or 2-2 and enter the proposed interior lighting equipment or interior lighting power density (LPD) for the entire building. However, if lighting plans will be submitted only for portions of the building, the ACM must require the user to select and input the occupancy type(s) from Table 2-2 and enter the actual lighting levels for portions of the building with lighting plans.

ACMs must allow the user to input a Tailored Lighting Input, lighting control credits and the fraction of light heat rejected to indirectly conditioned spaces for each zone.

The Tailored Lighting Input is the lighting power density specified on prescriptively-complying set of lighting plans that is less than or equal to the allowed watts on the corresponding approved set of Tailored Lighting Forms (LTG-4). Tailored lighting inputs are designed to allow special lighting applications to comply, but to be used they must correspond to specific needs and the particular design and the plans and specifications used to meet those needs. These plans must be capable of independent compliance approval at the light levels specified.

If a value is input for the Tailored Lighting Input, the ACM shall output on the compliance forms that Tailored Lighting loads have been used in compliance and that all necessary Tailored Lighting Forms and Worksheets documenting the lighting and its justification must be provided as part of the compliance documentation and be approved independently.

If a value is input for lighting control credits, the ACM shall output on the compliance forms that lighting control credits have been used in compliance and that the lighting Control Credit Watts from Column I for Zone Total from LTG-3, for the applicable zone, Lighting Controls Credit Worksheet have been used as the lighting control credit inputs.

DOE Keyword: LIGHTING-SCHEDULE
LIGHTING-W/SQFT
LIGHT-TO-SPACE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The proposed design lighting level is restricted based on which of the above two conditions is selected by the user for the building. The proposed design lighting level is determined as follows:

1. *Lighting compliance not performed*. The proposed design lighting level shall be the lighting level listed in Table 2-1 or 2-2. ACMs must report the default lighting energy on PERF-1 and indicate that no lighting compliance was performed. ACMs **must not** print any Lighting forms.

2. *Lighting compliance performed*. The proposed design lighting level for each space shall be as follows:

   a) Nonresidential occupancies: For each space the proposed design lighting level shall be the actual lighting level of the space as shown in the construction documents and lighting compliance documentation. For each space without specified lighting level, ACMs shall select the *default* lighting level from Table 2-2 according to the occupancy type of the space.

b) High-rise residential and hotel/motel occupancies: User inputs for lighting (and lighting controls) for the residential units and hotel/motel guest rooms must be ignored and the lighting levels determined from Table 2-2 must be used.

ACMs **must** print all applicable lighting forms and report the lighting energy use and the lighting level (Watts/ft^2) for the entire project. ACMs **must** report "No Lighting Installed" for nonresidential spaces with no installed lighting. ACMs must report "Default Residential Lighting" for residential units of high rise residential buildings and hotel/motel guest rooms.

If the *modeled* Lighting Power Density (LPD) is different than the *actual* LPD calculated from the fixture schedule for the building, ACMs shall model the larger of the two values for sizing the mechanical systems and for the compliance run. ACMs shall report the larger value on PERF-1. Lighting levels shall be adjusted by any lighting Control Credit Watts, if input by the user.

Modeling Rules for Reference Design (New & Altered Existing): ACMs shall determine standard design lighting level as follows:

1. *Lighting compliance not performed*. The standard design lighting level shall be the same as the proposed design lighting level.

2. *Lighting compliance performed*. If no Tailored Lighting Allotment is input and lighting plans will be submitted for the entire building (excluding the residential units of high-rise residential buildings and hotel/motel guest rooms), the standard design lighting level shall be determined from the same Table used for the proposed design. If lighting plans will be submitted only for portions of the building, the standard design lighting level shall be the lighting level listed in Table 2-2. If a Tailored Lighting Allotment is input, the standard design lighting level shall be the Tailored Lighting Allotment.

Modeling Rules for Reference Design (Existing Unchanged): ACMs shall determine the standard design lighting level of each space the same as it occurs in the existing design.

2.3.3 Occupancy Schedules

2.3.3.1 Schedule Types

Description: Schedules are either "Nonresidential," "Hotel Function," or "Residential."

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must select the schedule type from Table 2-3.

Modeling Rules for Reference Design (All): The standard design shall use the same schedule type as the proposed design except for the residential units of high-rise residential buildings ~~and hotel/motel guest rooms~~ with or without setback thermostat for which the standard design shall *always* use the schedule type with setback thermostat (Table 2-6).

2.3.3.2 Weekly Schedules

Description: The reference method has three different schedules for different days of the week: (1) Weekdays, (2) Saturdays, and (3) Sundays (which includes holidays). Weekly schedules specify: a) the percentage of full load for internal gains; b) thermostat set points for heating and cooling systems; and, c) hours of operation for heating, cooling and ventilation systems.

DOE Keyword: SCHEDULE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall use the weekly schedules in Tables 2-4 and 2-5 for nonresidential and hotel/motel occupancies respectively. For high-rise residential occupancies, ACMs shall require the user to enter whether the proposed design uses setback or non-setback thermostats for heating. ACMs shall use either Table 2-6 or Table 2-7 depending on whether the building uses setback thermostats for heating or uses non-setback thermostats.

Modeling Rules for Reference Design (All): The standard design shall use the same weekly schedules as the proposed design for nonresidential and hotel/motel occupancies. For high-rise residential occupancies the standard design shall use the weekly schedules in Table 2-6 assuming setback thermostats for the heating mode.

Table 2-3: Schedule Types of Occupancies & Sub-Occupancies

Occupancy or Sub-Occupancy Type	Schedule
Auditorium	Table 2-4: Nonresidential
Auto Repair Workshop	Table 2-4: Nonresidential
Bank/Financial Institution	Table 2-4: Nonresidential
Bar, Cocktail Lounge and Casino	Table 2-4: Nonresidential
Barber and Beauty Shop	Table 2-4: Nonresidential
Classroom	Table 2-4: Nonresidential
Courtrooms	Table 2-4: Nonresidential
Commercial/Industrial Storage	Table 2-4: Nonresidential
Commercial/Industrial Work-General	Table 2-4: Nonresidential
Commercial/Industrial Work-Precision	Table 2-4: Nonresidential
Convention, Conference and Meeting Center	Table 2-4: Nonresidential
Corridor, Restroom, and Support Area	Table 2-4: Nonresidential
Dining Area	Table 2-4: Nonresidential
Dry Cleaning (Coin Operated)	Table 2-4: Nonresidential
Dry Cleaning (Full Service Commercial)	Table 2-4: Nonresidential
Electrical and Mechanical Room	Table 2-4: Nonresidential
Exercising Centers and Gymnasium	Table 2-4: Nonresidential
Exhibit Display Area and Museum	Table 2-4: Nonresidential
Grocery Sales Area	Table 2-4: Nonresidential
High-rise Residential with Setback Thermostat	Table 2-6: Residential / with Setback
High-rise Residential without Setback Thermostat	Table 2-7: Residential / without Setback
Hotel Function Area	Table 2-5: Hotel Function
Hotel/Motel Guest Room with Setback Thermostat	Table 2-6: Residential / with Setback
Hotel/Motel Guest Room without Setback Thermostat	Table 2-7: Residential / without Setback
Kitchen and Food Preparation	Table 2-4: Nonresidential
Laundry	Table 2-4: Nonresidential
Library - Reading Areas	Table 2-4: Nonresidential
Library - Stacks	Table 2-4: Nonresidential
Lobby - Hotel	Table 2-5: Hotel Function
Lobby - Main Entry and Assembly	Table 2-4: Nonresidential
Lobby - Office Reception/Waiting	Table 2-4: Nonresidential
Locker and Dressing Room	Table 2-4: Nonresidential
Mall, Arcade and Atrium	Table 2-4: Nonresidential
Medical and Clinical Care	Table 2-4: Nonresidential
Office	Table 2-4: Nonresidential
Police Station and Fire Station	Table 2-4: Nonresidential
Religious Worship	Table 2-4: Nonresidential
Retail Sales and Wholesale Showroom	Table 2-4: Nonresidential
Smoking Lounge	Table 2-4: Nonresidential
Theater (Motion Picture)	Table 2-4: Nonresidential
Theater (Performance)	Table 2-4: Nonresidential
Unknown	Table 2-4: Nonresidential

Table 2-4: Nonresidential Occupancy Schedules

	Hour																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
HEATING (°F)																								
Weekday	55	55	55	55	55	63	68	70	70	70	70	70	70	70	70	70	70	70	70	55	55	55	55	55
Saturday	55	55	55	55	55	63	68	70	70	70	70	70	70	70	55	55	55	55	55	55	55	55	55	55
Sunday	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
COOLING (°F)																								
Weekday	95	95	95	95	95	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	95	95	95	95
Saturday	95	95	95	95	95	74	74	74	74	74	74	74	74	74	74	95	95	95	95	95	95	95	95	95
Sunday	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
LIGHTS (%)																								
Weekday	5	5	5	5	5	5	5	5	90	90	90	90	90	90	90	90	90	90	40	5	5	5	5	5
Saturday	5	5	5	5	5	5	5	5	90	90	90	90	40	30	5	5	5	5	5	5	5	5	5	5
Sunday	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
EQUIPMENT (%)																								
Weekday	5	5	5	5	5	5	5	5	50	50	50	50	30	50	50	50	50	50	35	5	5	5	5	5
Saturday	5	5	5	5	5	5	5	5	25	25	25	25	25	15	5	5	5	5	5	5	5	5	5	5
Sunday	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FANS (%)																								
Weekday	off	off	off	off	off	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	off	off	off	off
Saturday	off	off	off	off	off	on	on	on	on	on	on	on	on	on	on	off	off	off	off	off	off	off	off	off
Sunday	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off
INFILTRATION (%)																								
Weekday	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100
Saturday	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100
Sunday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
PEOPLE (%)																								
Weekday	0	0	0	0	0	0	0	5	50	50	50	30	30	50	50	50	50	50	30	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	5	15	15	15	15	5	5	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOT WATER (%)																								
Weekday	0	0	0	0	0	0	0	10	50	50	70	90	90	50	50	70	50	50	10	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	10	10	20	20	20	10	10	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2-5: Hotel Function Occupancy Schedules

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
HEATING (°F)																								
Weekday	55	55	55	55	55	55	63	68	70	70	70	70	70	70	70	70	70	70	70	70	70	70	55	55
Saturday	55	55	55	55	55	55	63	68	70	70	70	70	70	70	70	70	70	70	70	70	70	70	55	55
Sunday	55	55	55	55	55	55	63	68	70	70	70	70	70	70	70	70	70	70	70	70	70	70	55	55
COOLING (°F)																								
Weekday	95	95	95	95	95	95	95	95	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	95
Saturday	95	95	95	95	95	95	95	95	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	95
Sunday	95	95	95	95	95	95	95	95	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	95
LIGHTS (%)																								
Weekday	5	5	5	5	5	5	5	5	25	50	90	90	90	90	90	90	75	50	50	50	50	10	5	5
Saturday	5	5	5	5	5	5	5	5	25	50	90	90	90	90	90	90	75	50	50	50	50	10	5	5
Sunday	5	5	5	5	5	5	5	5	25	50	90	90	90	90	90	90	75	50	50	50	50	10	5	5
EQUIPMENT (%)																								
Weekday	5	5	5	5	5	5	5	5	50	50	50	50	30	50	50	50	30	10	30	30	30	10	5	5
Saturday	5	5	5	5	5	5	5	5	50	50	50	50	30	50	50	50	30	10	30	30	30	10	5	5
Sunday	5	5	5	5	5	5	5	5	50	50	50	50	30	50	50	50	30	10	30	30	30	10	5	5
FANS (%)																								
Weekday	off	off	off	off	off	off	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	off
Saturday	off	off	off	off	off	off	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	off
Sunday	off	off	off	off	off	off	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	off
INFILTRATION (%)																								
Weekday	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Saturday	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Sunday	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
PEOPLE (%)																								
Weekday	0	0	0	0	0	0	0	5	35	90	90	90	25	90	90	90	50	25	50	50	50	10	0	0
Saturday	0	0	0	0	0	0	0	5	35	90	90	90	25	90	90	90	50	25	50	50	50	10	0	0
Sunday	0	0	0	0	0	0	0	5	35	90	90	90	25	90	90	90	50	25	50	50	50	10	0	0
HOT WATER (%)																								
Weekday	0	0	0	0	0	0	10	40	40	60	60	60	90	60	60	60	60	40	50	50	50	10	0	0
Saturday	0	0	0	0	0	0	10	40	40	60	60	60	90	60	60	60	60	40	50	50	50	10	0	0
Sunday	0	0	0	0	0	0	10	40	40	60	60	60	90	60	60	60	60	40	50	50	50	10	0	0

Table 2-6: Residential Occupancy Schedules (Including Hotel/Motel Guest Rooms) With Setback Thermostat For Heating

	Hour																						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
HEATING (°F)																								
Weekday	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
Saturday	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
Sunday	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
COOLING (°F)																								
Weekday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Saturday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sunday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
LIGHTS (%)																								
Weekday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Saturday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Sunday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
EQUIPMENT (%)																								
Weekday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Saturday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Sunday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
FANS (%)																								
Weekday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Saturday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Sunday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
INFILTRATION (%)																								
Weekday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Saturday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Sunday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
PEOPLE (%)																								
Weekday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Saturday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Sunday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
HOT WATER (%)																								
Weekday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
Saturday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
Sunday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5

Table 2-7: Residential Occupancy Schedules (Including Hotel/Motel Guest Rooms) Without Setback Thermostat

	Hour																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
HEATING (°F)																								
Weekday	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Saturday	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Sunday	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
COOLING (°F)																								
Weekday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Saturday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Sunday	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
LIGHTS (%)																								
Weekday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Saturday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Sunday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
EQUIPMENT (%)																								
Weekday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Saturday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Sunday	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
FANS (%)																								
Weekday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Saturday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Sunday	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
INFILTRATION (%)																								
Weekday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Saturday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Sunday	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
PEOPLE (%)																								
Weekday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Saturday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Sunday	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
HOT WATER (%)																								
Weekday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
Saturday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
Sunday	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5

2.3.3.3 Holiday Schedules

Description: The reference method has Weekdays, Saturdays and Sundays schedules which includes holidays. The 1991 calendar year is a fixed input, with January 1st being a Tuesday, and the following holidays observed:

New Year's Day	Tuesday, January 1
Martin Luther King's Birthday	Monday, January 21
Washington's Birthday	Monday, February 18
Memorial Day	Monday, May 27
Independence Day	Thursday, July 4
Columbus Day	Monday, October 14
Veteran's Day	Monday, November 11
Thanksgiving Day	Thursday, November 28
Christmas Day	Wednesday, December 25

DOE Keyword: SCHEDULE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The proposed design shall use the Sunday occupancy schedule for the above holidays.

Modeling Rules for Reference Design (All): The reference design shall use the same schedule as the proposed design.

2.4 Building Systems & Plants - Required Capabilities

ACMs must have the capability to accept input for and model various types of HVAC systems. In central systems, these modeling features affect the system loads seen by the plant. A key factor related to equipment type is the energy source (electricity, natural gas, fuel oil, or LPG). For electric systems, ACMs must correctly apply the source multiplier (for example, 1 kWh = 10,239 source Btu) as stated in Table No. 1-B of the Standards.

Minimum ACM requirements for equipment that are typically used in larger systems, such as chillers, boilers, pumps and service water heaters, are described in this section.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being “All.” An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as “All.”

2.4.1 Thermal Zoning

2.4.1.1 Thermal Zones

Description: A space or collection of spaces within a building having sufficiently similar space-conditioning requirements that those conditions could be maintained with a single controlling device.

ACMs must accept input for and be capable of modeling a minimum of fifty (50) thermal zones, each with its own thermostatic control. ACMs must also require a building level input for the number of thermostats. When the number of thermostats is not greater than twenty (20) the ACM must have one HVAC zone per thermostat. An ACM may use zone multipliers for identical zones.

When the number of zones exceeds twenty, then (and only then) thermal zones may be combined subject to a variety of rules and restrictions. See Chapter 4 for details on restrictions on combining thermal zones and requirements for zoning buildings for which no HVAC permit is sought.

DOE Keyword: ZONE
ZONE-TYPE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference method models thermal zones as input by the user according to the plans and specifications for the building. If no thermal zones are shown on the building plans, ACMs shall inform the user to follow the guidelines described in Chapter 4--Compliance Supplement. These guidelines must be included in the ACM's Compliance Supplement and repeated in the user's manual. **It is not adequate or appropriate to reference this manual to relay this information to the user. The absence of such information and modeling rules in the ACM's user documentation is sufficient grounds for rejecting an ACM for compliance use.**

Modeling Rules for Reference Design (All): ACMs shall model the thermal zones of the reference design in the same manner as they are modeled in the proposed design.

2.4.2 Heating & Cooling Equipment

2.4.2.1 Primary Systems

Description: The ACM must be able to model the following primary systems:

- *Hydronic*. Primary system cooling/heating coil served by a central hydronic system.
- *Electric*. Primary system heating using electric resistance.

- *Fossil fuel furnace.* Primary system heating by a fossil fuel fired furnace.
- *Heat pump.* Primary system heating provided by direct expansion refrigerant coils served by a heat pump.
- *DX (Direct Expansion).* Primary system cooling provided by direct expansion refrigerant coils served by a heat pump or other compression system.

2.4.2.2 Cooling Equipment

Description: The ACM must account for variations in cooling equipment efficiency and capacity. ACMs will be compared to and tested against a reference method that also accounts for variations in efficiency and capacity as a function of part-load ratio and heat transfer fluid (e.g., chilled water, condenser water, outside air for air-cooled systems) temperatures. The ACM user must be able to explicitly enter equipment type and capacity and standard efficiency ratings (such as SEER and/or EER for packaged equipment).

In certain cases the standards allow cooling equipment to be installed below the mandatory minimum efficiency ratings listed in the standards for new currently manufactured equipment, e.g. existing equipment moved to a new location in the building. If an ACM allows efficiencies to be entered (optional entry and capability) lower than those indicated in the mandatory features for newly manufactured equipment, then those entries must also be indicated in the exceptional conditions checklist on the PERF-1 and be justified in writing.

ACMs must model two fundamental types of cooling equipment:

1. *Water chillers.* Cooling equipment that chills water to be supplied to building coils.

2. *Direct expansion (DX) compressors.* Cooling systems that directly cool supply air without first cooling a heat transfer medium such as water. See descriptions above for other definitions.

The reference method models part-load performance for at least two different types of water chillers and **all ACMs must allow the user to select either of these two chiller types**:

1. *Centrifugal.* Compression refrigeration system using rotary centrifugal compressor.

2. *Reciprocating.* Compression refrigeration system using reciprocating positive displacement compressor.

2.4.2.3 Heating Equipment

Description: The ACM must account for variations in heating equipment performance according to efficiency and as a function of load. The user must be able to explicitly enter equipment type and capacity and rated efficiency (such as AFUE, Steady State Thermal Efficiency or HSPF).

In certain cases the standards allow heating equipment to be installed below the mandatory minimum efficiency ratings listed in the standards for new currently manufactured equipment, e.g. existing equipment moved to a new location in the building. If an ACM allows efficiencies to be entered (optional entry and capability) lower than those indicated in the mandatory features for newly manufactured equipment, those entries must also be indicated in the exceptional conditions checklist on the PERF-1 and be justified in writing.

ACMs must model three fundamental types of heating equipment:

1. *Furnaces*. The following forced air furnaces must be provided:

- *Electric*. Electric resistance elements used as the heating source.
- *Fossil Fuel*. Natural gas or liquid propane is used as the heating source.

2. *Boilers*. The following capabilities must be provided for boilers:

- *Electric*. Boiler uses electric resistance heating.
- *Fossil Fuel*. Boiler is natural gas or oil fired.
- *Natural draft*. Fossil fired boiler uses natural draft (atmospheric) venting.
- *Forced/induced draft*. Fossil fired boiler uses fan forced or induced draft venting. With this option, the ACM must account for fan energy.
- *Hot water*. Boiler produces hot water.

3. *Heat Pumps*. Supply air is heated through direct expansion process utilizing electricity as the fuel type and outside air as the heat source.

2.4.2.4 Standard Design Systems

Description: The reference method will assign one of five *Standard Design System* types for all proposed HVAC systems in order to establish an energy budget for the standard building. This system is generated and modeled for all buildings, even if no mechanical heating or cooling is included in the building permit.

ACMs must require the user to input the following for each system:

1. **Building Type** - low-rise nonresidential, high-rise nonresidential, residential and hotel/motel guest room

2. **System Type** - single zone, multiple zone

3. **Heating Source** - fossil fuel, electricity

4. **Cooling Source** - hydronic, other (for high-rise residential and hotel/motel guest room, only)

The following definitions apply to the terms listed above:

Low-rise nonresidential: A building which is of occupancy group A, B, E, or H with three or less habitable stories.

High-rise nonresidential: A building which is of occupancy group A, B, E, or H with four or more habitable stories

High-rise residential: A building, other than a hotel/motel, of occupancy group R-1 with four or more habitable stories.

Hotel and motel guest room: The guest rooms of a Hotel/Motel as defined in Section 101(b) of the Standards.

Single zone: A supply fan (and optionally a return fan) with heating and cooling heat exchangers (e.g. DX coil, chilled water coil, hot water coil, furnace, electric heater) that serves a single thermostatic zone. This system may or may not be constant volume.

Multiple zone: A supply fan (and optionally a return fan) with heating and/or cooling heat exchangers (e.g. DX coil, chilled water coil, hot water coil, furnace, electric heater) that serves more than one thermostatic zone. Zones are thermostatically controlled by features including but not limited to variable volume, reheat, recool and concurrent operation of another system.

Fossil fuel: At least one source system heat is from a fossil fuel such as gas, oil, or coal.

Electric: Heating source is from electrically powered systems only such as electric resistance, heat pumps with no auxiliary heat or with electric auxiliary heat, solar with electric back-up, etc.

Hydronic: Any cooling system which uses water or a water solution as a source of cooling or heat rejection, including chilled water systems (both air and water-cooled) as well as water-cooled or evaporatively cooled direct expansion systems such as water source (water-to-air) heat pumps.

All ACMs must accept input for and be able to model the following system types for both the standard and proposed design:

- **System 1: Packaged Single Zone (PSZ), Gas furnace and electric air conditioner**

- **System 2: Packaged Single Zone (PHP), Electric heat pump and air conditioner**

- **System 3: Packaged Variable Air Volume (PVAV), Central gas boiler with hydronic reheat and electric air conditioner**

- **System 4: Built-up Variable Air Volume (VAV), Central gas boiler with**

hydronic reheat and central electric chiller with hydronic air conditioning

- System 5: **Four-pipe fan coil (FPFC), Central gas boiler and electric chiller serving individual units with hydronic heating and cooling coils.**

DOE Keyword: SYSTEM-TYPE

Input Type: Prescribed

Tradeoffs: N/A

Modeling Rules for Proposed Design: The proposed system shall be input as it is shown in the construction documents for the building.

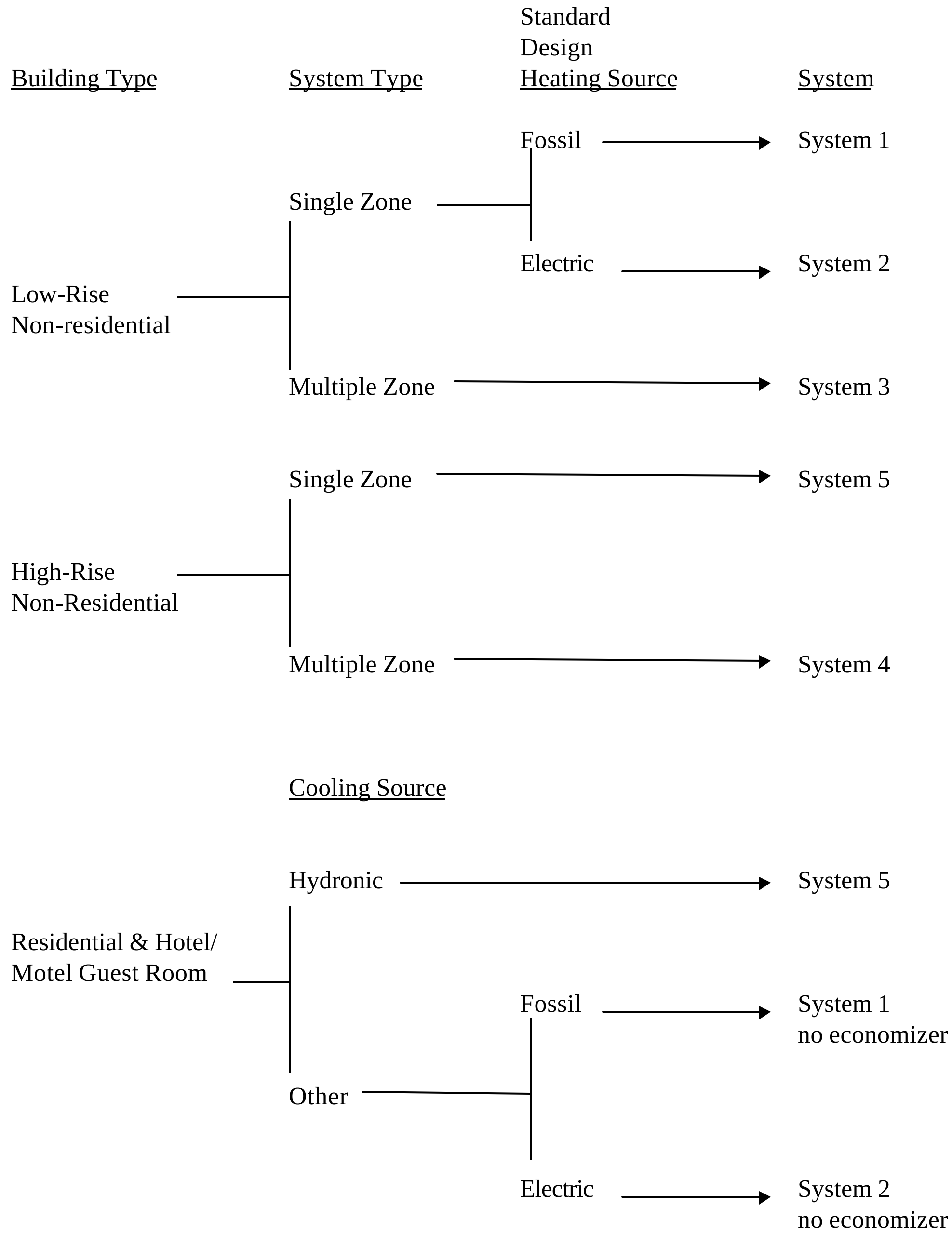
ACMs must receive enough input about the proposed system to: 1) generate the applicable standard design system; 2) apply all required efficiency descriptors to both the standard and proposed designs; and, 3) model the energy use of the proposed design accurately.

Modeling Rules for Reference Design (New): The reference design system selection is shown in Figure 2-1. The reference method chooses the standard HVAC system only from the five minimum systems listed above. The reference method will select its standard system according to Figure 2-1, for the standard design system, regardless of the system type chosen for the proposed design. For example, a hydronic heating system served by a gas-fired boiler to supply hot water to the loop for a low-rise nonresidential building is considered a single zone (fan) system with fossil fuel for a heating source, and would be compared to System #1 - a Packaged Single Zone Gas/Electric System. Likewise a gas-fired absorption cooling system with a gas-fired furnace serving a single zone would be compared to System #1 also. Figures 2-2a through 2-2d describe the five standard design system types.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing) : The reference design shall model the existing system with its rated efficiency. If the entered efficiency is lower than those indicated in the mandatory features for newly manufactured equipment, then those entries must also be indicated in the exceptional conditions checklist on the PERF-1 and be noted as existing system.

Figure 2-1: Standard Design System Selection Flowchart

Systems Comparison Chart



Standard Design Systems

System 1:	Packaged Single Zone, Gas/Electric
System 2:	Packaged Single Zone, Heat Pump
System 3:	Packaged VAV, Gas Boiler with Reheat
System 4:	Central VAV, Gas Boiler with Reheat
System 5:	Four Pipe Fan Coil System with Central Plant

Figure 2-2a: System #1 and System #2 Descriptions

System Description:	Packaged Single Zone with Gas Furnace/Electric Air Conditioning (#1) or Heat Pump (#2)
Supply Fan Power:	See Section 2.4.2.22
Supply Fan Control:	Constant volume
Min Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 55
Cooling System:	Direct expansion (DX)
Cooling Efficiency:	Minimum SEER or EER based on equipment type and output capacity of proposed unit(s). Adjusted EER is calculated to account for supply fan energy.
Maximum Supply Temp:	$85 \leq T \leq 110$ DEFAULT: 100
Heating System:	Gas furnace (#1) or heat pump (#2)
Heating Efficiency:	Minimum AFUE, Thermal Efficiency, COP or HSPF based on equipment type and output capacity of proposed unit(s).
Economizer:	Integrated dry-bulb economizer, when mechanical cooling output capacity of the proposed design as modeled in the compliance run by the ACM is over 75,000 Btu/hr and fan system volumetric capacity of the proposed design as modeled in the compliance run by the ACM is over 2500 cfm
Ducts:	For ducts installed in spaces between insulated ceiling and roof or exterior to the building, the duct system efficiency shall be as described in Section 2.4.2.35

Figure 2-2b: System #3 Description

System Description:	Packaged VAV with Boiler and Reheat
Supply Fan Power:	See Section 2.4.2.22
Supply Fan Control:	Individual VAV supply fan with 25 horsepower and less: VAV - forward curved fan with discharge damper Individual VAV supply fan greater than 25 horsepower: VAV - variable speed drive
Return Fan Control:	Same as supply fan
Minimum Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 55
Cooling System:	Direct expansion (DX)
Cooling Efficiency:	Minimum efficiency based on average proposed output capacity of equipment unit(s)
Maximum Supply Temp:	$90 \leq T \leq 110$ DEFAULT: 105
Heating System:	Gas boiler
Heating Efficiency:	Minimum efficiency based on average proposed output capacity of equipment unit(s)
Economizer:	Integrated dry-bulb economizer, when mechanical cooling output capacity of the proposed design as modeled in the compliance run by the ACM is over 75,000 Btu/hr and fan system volumetric capacity of the proposed design as modeled in the compliance run by the ACM is over 2500 cfm

Figure 2-2c: System #4 Description

System Description:	Chilled Water VAV With Reheat
Supply Fan Power:	See Section 2.4.2.22
Supply Fan Control:	Individual VAV supply fan with 25 horsepower and less: VAV - forward curved fan with discharge damper Individual VAV supply fan greater than 25 horsepower: VAV - variable speed drive
Return Fan Control:	Same as supply fan
Minimum Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 55
Cooling System:	Chilled water
Cooling Efficiency:	Minimum efficiency based on average proposed output capacity of equipment unit(s)
Maximum Supply Temp:	$90 \leq T \leq 110$ DEFAULT: 105
Heating System:	Gas boiler
Heating Efficiency:	Minimum efficiency based on average proposed output capacity of equipment unit(s)
Economizer:	Integrated dry-bulb economizer, when mechanical cooling output capacity of the proposed design as modeled in the compliance run by the ACM is over 75,000 Btu/hr and fan system volumetric capacity of the proposed design as modeled in the compliance run by the ACM is over 2500 cfm

Figure 2-2d: System #5 Description

System Description:	Four-Pipe Fan Coil With Central Plant
Supply Fan Power:	See Section 2.4.2.22
Minimum Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 55
Cooling System:	Chilled water
Cooling Efficiency:	Minimum efficiency based on the proposed output capacity of specific equipment unit(s)
Maximum Supply Temp:	$90 \leq T \leq 110$ DEFAULT: 100
Heating System:	Gas boiler
Heating Efficiency:	Minimum efficiency based on the proposed output capacity of specific equipment unit(s)
Economizer:	Integrated dry-bulb economizer, when mechanical cooling output capacity of the proposed design as modeled in the compliance run by the ACM is over 75,000 Btu/hr and fan system volumetric capacity of the proposed design as modeled in the compliance run by the ACM is over 2500 cfm

2.4.2.5 Combining Like Systems

Description: When several similar thermal zones with similar *heating/cooling units* are combined (see Section 4.3.3.1 for conditions that lead to thermal zones being similar) or similar *heating/cooling units* with similar controls serve a thermal zone, the ACM may combine the system heating and cooling capacities, supply air flow rates, and fan power for the zone.

The ACM must require the user to input the number of such systems. The ACM shall receive a value for this input for fan systems, packaged heating or cooling equipment, chillers and boilers. The efficiency of the combined system shall be the weighted average of efficiencies of all systems based on the size of each unit.

If the user inputs a value greater than 1 for the *number of heating/cooling units*, the ACM must print a warning on the Performance Summary form, PERF-1, indicating that systems of similar type have been modeled as one system and that a prescriptive Mechanical Equipment Summary form, MECH-3, must be attached documenting each individual system. Refer to Chapter 4, Section 4.3.3.19 for discussion of allowed like system types.

DOE Keyword: N/A

Input Type: Default

Tradeoffs: N/A

Modeling Rules for Proposed Design: The reference program shall model one heating/cooling unit with heating and cooling capacities, supply air flow rate, and fan power equal to the total capacities, air flow rates, and fan power of the combined systems. The efficiency shall be equal to the capacity weighted average efficiency for the systems being combined.

Default: One system

Modeling Rules for Reference Design (All): The reference program shall model the standard design using *Standard Design System* types and the applicable capacities, supply air flow rate, fan power, and the minimum efficiency requirements.

2.4.2.6 Equipment Performance Curves (except for electric chillers)

Description: The reference method will model the performance curves of mechanical heating and cooling equipment as functions of variables such as part-load ratio, outside dry-bulb and wet-bulb temperatures, return air dry-bulb and wet-bulb temperatures and air flow rate. These reference method performance curves are those specified in the DOE 2 Reference Manual (Version 2.1E) Supplement, Lawrence Berkeley Laboratory Document #LBL-8706, Rev. 5. The performance curves for electric chillers are discussed in Section 2.4.2.33.

DOE Keyword: CURVE-FIT

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference method will use the performance curves for equipment specified in the DOE 2 Reference Manual (Version 2.1E) Supplement or other default relationships as specified in this manual.

Modeling Rules for Reference Design (All): The reference method will use the same performance curves as the proposed design.

2.4.2.7 Cooling Efficiency of DOE Covered Air Conditioners

Description: ACMs must require the user to input the SEER (seasonal energy efficiency ratio) of any DOE-covered consumer product. ACMs must allow the user to input the EER (energy efficiency ratio), however the ACM must not require this input for HVAC equipment that is covered by the U.S. DOE appliance standards.

ACMs must also use the ARI net cooling capacity input by the user, as required by this chapter, and the ARI tested fan power and part load capacity as calculated according to this chapter. These three values are also necessary to model efficiency of DOE-covered consumer products.

Modeling of SEER is achieved through accounting for the Electrical Input Ratio, EIR, and total system cooling capacity as functions of Outside Dry-Bulb (ODB) and Coil Entering Wet-Bulb (WB) temperatures, and through accounting for duct efficiency impacts on EIR.

The reference method is based on a created performance curve, similar to the DOE 2.1

curve COOL-EIR-FT, using the following points for WB, ODB and N_{eir}, respectively. This new curve is given below in terms of the reference computer program curve-fit instruction. For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the COOL-EIR-SEER shall be divided by the seasonal distribution efficiency as determined in Section 2.4.2.35.

COOL-EIR-SEER = CURVE-FIT
TYPE = BI-QUADRATIC
DATA = (67,95,1.0)
(67,82,N_{eirb})
(67,110,1.174)
(67,105,1.113)
(67,70,$N_{eir70/67adj}$)
(80,95,0.897)
(50,95,1.070) ..

where N_{eirb} and $N_{eir70/67adj}$ are calculated as follows:

1. ACMs must first calculate an EER_b from the following equation:

$$EER_b = \frac{SEER}{1 - 0.5 \times C_d}$$

Equation 2.4.1

where:

EER_b = Energy Efficiency Ratio at DOE part-load conditions. [Btuh/watt]

C_d = Cyclical degradation coefficient at DOE part-load conditions

2. If the EER is not input, calculate EER from the following equation:

$$EER = 0.855 \times EER_b$$

Equation 2.4.2

3. Calculate the electrical input ratio, EIR_a, at ARI conditions according to the following equation:

$$EIR_a = \frac{(CAP_a / EER) - ARIFanPower}{(CAP_a / 3.413) + ARIFanPower}$$

Equation 2.4.3

ARI Fan Power = The power [watts] used by the supply fan for the purpose of performing ARI, CEC and DOE approved tests (See ***ARI Fan***

Power.)

CAP_a = The net cooling capacity at ARI conditions of 95 outside dry-bulb(ODB) and 67 coil entering wet-bulb (WB) [Btuh]

4. Calculate the electrical input ratio, EIR_b, at ARI part-load conditions according to the following equation:

$$EIR_b = \frac{(CAP_b / EER_b) - ARIFanPower}{(CAP_b / 3.413) + ARIFanPower}$$

Equation 2.4.4

where:

EER_b = From Equation 2.4.1 above. [Btuh/watts]

EIR_b = The electrical input ratio [unitless], or cooling electrical efficiency of the piece of equipment at ARI part-load conditions

CAP_b = The net cooling capacity [Btuh] at ARI part-load conditions (82 ODB and 67 WB), given by the following equation:

$$CAP_b = 1.07 \times CAP_a$$

Equation 2.4.5

where

CAP_a= The net cooling capacity [Btuh] at ARI conditions of 95 outside dry-bulb (ODB) and 67 coil entering wet-bulb (WB)

5. Normalize EIR_b based on ARI conditions, 95 outside dry-bulb (ODB):

$N_{eirb} = EIR_b / EIR_a$ [unitless]

6. Calculate $N_{eir70/67adj}$ according to the following equation:

$N_{eir70/67adj} = 0.876 \, H \, N_{eirb}$ [unitless]

For heat pumps, the reference method uses performance curves based on the ratio of the COPs and CAPACITIES at 47^{o}F and at 17^{o}F (COP_{47}, COP_{17}, CAP_{47}, CAP_{17}) and creates new performance curves, similar to the DOE 2.1 COOL-EIR-FT and COOL-CAP-FT, using the following points for ODB and the COPs and CAPACITIES at these temperatures. For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the HP-EIR-FT shall be divided by the seasonal distribution efficiencies as determined in Section

2.4.2.35.

HP-EIR-FT = CURVE-FIT
TYPE = CUBIC
DATA = (67,0.856)
(57,0.919)
(47,1.000)
(17,COP_{47}/COP_{17})
(7,1.266×COP_{47}/COP_{17})
(-13, 3.428) ..

HP-CAP-FT = CURVE-FIT
TYPE = CUBIC
DATA = (67,1.337)
(57,1.175)
(47,1.000)
(17,CAP_{17}/CAP_{47})
(7,0.702×CAP_{17}/CAP_{47})
(-13, 0.153) ..

DOE Keyword: COOLING-EIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall require users to input a value for SEER and shall allow users to input a value for EER. ACMs shall use 0.03 for the cyclical degradation coefficient C_d. The reference method uses user input values to generate the required performance curves for the proposed design.

Default: Minimum SEER and EER as specified in the Appliance Efficiency Regulations

Modeling Rules for Reference Design (New): The ACM shall assign standard design performance data for the above functions according to the following criteria:

a) If the proposed design system is a *single package* unit according to the CEC Appliance Efficiency Standards, the standard design shall use an EER of 8.6, an SEER of 9.9 and a C_d of 0.03 to develop the required performance curves.

b) If the proposed design system is a *split system* according to the CEC Appliance Efficiency Standards, the standard design shall use an EER of 8.7, an SEER of 10.0 and a C_d of 0.03 to develop the required performance curves.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): The ACM shall assign standard design performance data for the above functions according to the following criteria:

a) If the existing system is a *single package* unit according to the CEC Appliance Efficiency Standards, the standard design shall use the EER or the SEER of the existing system and a C_d of 0.03 to develop the required performance curves.

b) If the existing system is a *split system* according to the CEC Appliance Efficiency Standards, the standard design shall use the EER or the SEER of the existing system and a C_d of 0.03 to develop the required performance curves.

The ACM shall use the ARI fan power of the existing system.

2.4.2.8 Cooling Efficiency of Packaged Equipment not Covered by DOE Appliance Standards

Description: ACMs shall require the user to input the EER for all packaged cooling equipment that are not covered by DOE appliance standards.

ACMs shall also require the user to input the net cooling capacity, CAPa, at ARI conditions for all cooling equipment.

For equipment where supply fan energy is included in the calculation of EER and CAPa, the reference method shall calculate the electrical input ratio, EIR, according to Equation 2.4.4.
For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the COOL-EIR shall be divided by the seasonal distribution efficiencies as determined in Section 2.4.2.35.

DOE Keyword: COOLING-EIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input efficiency descriptors at ARI conditions for all equipment documented in the plans and specifications for the building.

Default: Minimum EER as specified in the Appliance Efficiency Regulations

Modeling Rules for Reference Design (New): For the reference method, the standard design shall assign the EER and EIR of each unit according to the applicable requirements of the Appliance Efficiency Standards or the Standards. The EIR of the equipment will be based on the proposed system with an EER that meets the applicable requirements of the Standards but has the same cooling capacity and ARI fan power as the unit selected for the proposed design.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall use the EER, EIR, and the ARI fan power of the existing system. The EIR of the existing equipment must be based on the EER and the ARI fan power of the existing system.

2.4.2.9 Efficiency of Cooling Equipment Included in Built-up Systems

Description: ACMs must require the user to input: (1) the type of central cooling plant equipment proposed (e.g. open centrifugal, open reciprocating, water chiller, direct expansion, etc.); (2) the number of central cooling units and the capacity of each unit; (3) the efficiency of each central cooling unit; and (4) the type of refrigerant to be used in each central cooling unit. ACMs shall not accept user-defined performance curves for any equipment except for electric chillers.

DOE Keyword: COOLING-EIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input efficiency descriptors at ARI test conditions for all equipment documented in plans and specifications for the building.

Default: Minimum efficiency as specified in the Appliance Efficiency Regulations or Tables 1-C1 through 1-C7 of the Building Energy Efficiency Standards

Modeling Rules for Reference Design (New): Based on the capacity and type of chiller(s) the reference method assigns the EER of each unit of the standard design according to the applicable requirements of the Appliance Efficiency Standards or the Standards.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall use the EER and the ARI fan power of the existing system.

2.4.2.10 Heating Efficiency of DOE Covered Heat Pumps

Description: ACMs must require the user to input: (1) the Heating Seasonal Performance Factor (HSPF); (2) the heating capacity at 47 ODB; and, (3) the system configuration, either *single package* unit or *split system* for DOE covered heat pumps.

The reference method calculates an equivalent Coefficient Of Performance (COP) according to the following:

a) For *single package* units:

$$COP = (0.2778 \times HSPF + 0.9667)$$

Equation 2.4.6a

b) For *split systems*:

$$COP = (0.4813 \times HSPF - 0.2606)$$

Equation 2.4.6b

The reference method will calculate the total heating capacity at ARI conditions, $HCAP_{atot}$ of the heat pump according to the following equation:

$$HCAP_{atot} = HCAP_{a} - (3.413 \times ARIFanPower)$$

Equation 2.4.7

where the total capacity, $HCAP_{atot}$ is given in Btu per hour [Btuh] and ARIFanPower is rated in watts.

The reference method calculates the electrical heating input ratio, HIR, according to the following equation:

$$HIR = \frac{[HCAP_a / (COP \times 3.413)] - ARIFanPower}{(HCAP_a / 3.413) - ARIFanPower}$$

Equation 2.4.8

For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the HEATING-EIR shall be divided by the seasonal distribution efficiencies as determined in Section 2.4.2.35.

DOE Keyword: HEATING-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input all required data, as it occurs in the construction documents.

Default: Minimum COP as specified in the Appliance Efficiency Regulations

Modeling Rules for Reference Design (New): The reference method and all ACMs shall assign a COP of 2.8 to standard design *single package* units and 3.0 to standard design *split systems*.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall use the COP and the ARI fan power of the existing system.

2.4.2.11 Heating Efficiency of Heat Pumps not Covered by DOE Standards

Description: ACMs shall require the user to input the COP for all packaged heat pump equipment with fans that are not covered by DOE appliance standards.

ACMs shall also require the user to input the net heating capacity, $HCAP_a$, at ARI conditions for all equipment.

The reference method calculates the electrical heating input ratio, HIR, according Equation 2.4.8.
For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the HEATING-HIR shall be divided by the seasonal distribution efficiencies as determined in Section 2.4.2.35.

DOE Keyword: HEATING-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input efficiency descriptors as they occur in the construction documents.

Default: Minimum COP as specified in either the Appliance Efficiency Regulations or Table 1-C2 of the Building Energy Efficiency Standards.

Modeling Rules for Reference Design (New): For the reference method, the HIR of each unit in the standard design is determined according to the applicable requirements of the Appliance Efficiency Standards or the Standards.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall determine the HIR of each existing system using the COP and the ARI fan power of the existing system.

2.4.2.12 Heating Efficiency of DOE Covered Fan Type Central Furnaces

Description: ACMs shall require the user to input: (1) the AFUE; (2) the heating capacity; and (3) the system configuration for all DOE covered fan type central furnaces.

The reference method calculates an equivalent heating input ratio, HIR, according to the following:

a) For *single package* units:

$$HIR = (0.005163 \times AFUE + 0.4033)^{-1}$$

Equation 2.4.9a

b) For *split systems* with AFUEs not greater than 83.5:

$$HIR = (0.002907 \times AFUE + 0.5787)^{-1}$$

Equation 2.4.9b

c) For *split systems* with AFUEs greater than 83.5:

$$HIR = (0.011116 \times AFUE - 0.098185)^{-1}$$

Equation 2.4.9c

For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the HEATING-HIR shall be divided by the seasonal efficiencies as determined in Section 2.4.2.35.

DOE Keyword: HEATING-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall require the user to input the AFUE of each DOE covered central furnace.

Default: Minimum AFUE as specified in the Appliance Efficiency Regulations

Modeling Rules for Reference Design (New): The reference method assigns an HIR of 1.24 to all standard design heating systems when a fan-type central furnace is the proposed heating system.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall determine the HIR of each existing system using the AFUE of the existing system.

2.4.2.13 Heating Efficiency Fan Type Central Furnaces not Covered by DOE Standards

Description: The ACM shall require the user to input the steady state efficiency, or the HIR, of each furnace for each furnace's rated capacity.
For single-zone systems with ducts installed in spaces between insulated ceilings and roofs or building exteriors for which the verified sealed duct option has been elected, the HEATING-HIR shall be divided by the seasonal distribution efficiencies as determined in Section 2.4.2.35.

DOE Keyword: HEATING-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input efficiency descriptors as they occur in the construction documents.

Default: Minimum COP as specified in either the Appliance Efficiency Regulations or Table 1-C5 of the Building Energy Efficiency Standards.

Modeling Rules for Reference Design (New): The standard design shall assign the HIR of each unit according to the applicable requirements of the Standards.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall determine the HIR of each existing system using the AFUE of the existing system.

2.4.2.14 Efficiency of Boilers Covered by DOE Standards

Description: ACMs must require the user to input: (1) the type of central boiler proposed (steam or water, forced or induced draft, etc); (2) the number of central boilers and the capacity of each unit; (3) the heating input ratio of each boiler; and (4) the type of primary fuel used in each boiler. ACMs shall use the same boiler part-load curve for the proposed and standard designs. The reference method uses the DOE 2.1E default part-load curves for boilers. **ACMs are not allowed to accept user-defined part-load curves for boilers.**

ACMs shall calculate an equivalent heating input ratio, HIR, according to the following:

(a) $75 \leq \text{AFUE} < 80$

$$HIR = \left(0.1 \times AFUE + 72.5\right)^{-1} \times 100$$

Equation 2.4.10a

(b) $80 \leq \text{AFUE} < 100$

$$HIR = \left(0.875 \times AFUE + 10.5\right)^{-1} \times 100$$

Equation 2.4.10b

DOE Keyword: BOILER-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The reference method converts, to an HIR, the user input AFUE as documented in the plans and specifications for the building.

Default: Minimum AFUE as specified in the Appliance Efficiency Regulations

Modeling Rules for Reference Design (New): The standard design shall assign the HIR of each unit according to the applicable requirements of the Standards.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall determine the HIR of each existing system using the AFUE of the existing system.

2.4.2.15 Efficiency of Boilers not Covered by DOE Standards

Description: ACMs must require the user to input: (1) the type of central boiler proposed (steam or water, forced or induced draft, etc); (2) the number of central boilers and the capacity of each unit; (3) the heating input ratio of each boiler; and (4) the type of primary fuel used in each boiler. ACMs shall use the same boiler part-load curve for the proposed and standard designs. The reference method uses the DOE 2.1E default part-load curves for boilers.

DOE Keyword: BOILER-HIR

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input efficiency descriptors at required testing conditions for all equipment documented in the plans and specifications for the building and shall model all combustion air fans as input by the user.

Default: Minimum AFUE as specified in either the Appliance Efficiency Regulations or efficiency as specified in Table 1-C6 of the Building Energy Efficiency Standards.

Modeling Rules for Reference Design (New): The standard design shall use a boiler or boilers with an AFUE as specified in either the Appliance Efficiency Regulations or efficiency as specified in Table 1-C6 of the Building Energy Efficiency Standards ~~HIR of 1.25~~ in the reference method.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall determine the HIR of each existing system using the AFUE of the existing system.

2.4.2.16 Air-Cooled Condensers

Description: The reference method shall model air-cooled condensers as integral to the cooling plant equipment specified. Direct expansion compressors with air-cooled condensers shall include the EIR of the condenser with the EIR of the compressor. Air-cooled water chillers shall include the EIR of the condenser with the EIR of the chiller. The EIR shall be calculated according to Equation 2.4.3, except when supply/return fan heat is excluded by the manufacturer when calculating the EER. In that case, the EER shall be calculated according to the following equation:

$$EIR_a = \frac{(CAP_a / EER)}{(CAP_a / 3.413) + ARIFanPower}$$

Equation 2.4.3

Refer to Section 2.4.2.31 (Chiller Characteristics) for modeling rules for air-cooled chillers.

2.4.2.17 Electric Motor Efficiency

Description: The full-load efficiency of the electric motor established in accordance with NEMA Standard MG1. The standard design shall use the minimum nominal full-load efficiency shown in Table 2-8. For systems with multiple motors, the reference program combines the mechanical efficiencies as follows:

$$MEFF_{combine} = \frac{\sum_{i=1}^{n} (HP_i \times MEFF_i)}{\sum_{i=1}^{n} HP_i}$$

where

$MEFF_{combine}$ = Combined mechanical efficiency
$MEFF_i$ = Mechanical efficiency of the i^{th} motor
HP_i = Horsepower of the i^{th} motor
n = Total number of motors being combined

DOE Keyword: SUPPLY-MECH-EFF
RETURN-EFF

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall require the user to input the full-load efficiency for all electric motors documented in the plans and specifications for the building as established in accordance with NEMA Standard MG1.

Default: Standard motor efficiency from Table 2-8.

Modeling Rules for Reference Design (New): The reference design shall use the appropriate minimum efficiency values from Table 2-8.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): The reference design shall use the full-load efficiency of existing electric motors as established in accordance with NEMA Standard MG1. If the efficiency of the existing motor is not available the reference design shall use the default motor efficiency from Table 2-8.

Table 2-8: Minimum Nominal Efficiency for Electric Motors (%)

	Open Motors				**Enclosed Motors**			
Number of Poles	**2**	**4**	**6**	**8**	**2**	**4**	**6**	**8**
Synchronous Speed	**3600**	**1800**	**1200**	**900**	**3600**	**1800**	**1200**	**900**
Motor Horsepower								
1	-	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5

7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.0	95.4	94.5	95.4	95.0	95.0	94.5
300	95.0	95.4	95.4	-	95.4	95.4	95.0	-
350	95.0	95.4	95.4	-	95.4	95.4	95.0	-
400	95.4	95.4	-	-	95.4	95.4	-	-
450	95.8	95.8	-	-	95.4	95.4	-	-
500	95.8	95.8	-	-	95.4	95.8	-	-

2.4.2.18 ARI Fan Power

Description: The *ARI Fan Power* is required to calculate the electrical input ratios described above. The reference method determines the *ARI Fan Power* for systems 1, 2 and 3 by assuming that the *ARI Fan Power* is fixed at 365 watts per 1000 cfm with supply air flow rate fixed at 400 cfm per 12,000 Btuh net cooling capacity.

2.4.2.19 Fan System Configuration

Description: ACMs must model the configuration of fan systems as described below.

DOE Keyword: FAN-PLACEMENT
MOTOR-PLACEMENT

Input Type: Prescribed

Tradeoffs: N/A

Modeling Rules for Proposed Design: The proposed design system shall assume the following:

- For systems 1 through 4, all supply fans shall be "draw-through" type, positioned downstream from all heating and cooling sources.

- For system 5, the supply fan shall be a "blow-through " type, positioned upstream from heating and cooling sources.

- ACMs may combine return fans with the supply fan if and only if the controls are of the same type. For example, ACMs may combine fans if they all have variable speed drive control or if they all are constant volume fans.

  Return fans are those that are required to operate at design conditions to draw air from conditioned zones and can either return that air back to the source (the intake of the supply fan system) or exhaust it to the outdoors. Exhaust fans that are manually switched such as bathroom fans must not be included in the fan model.

- All fan motor heat shall be rejected to the supply air stream
.

Modeling Rules for Reference Design (All): All standard design fan configuration features shall be the same as the proposed design.

2.4.2.20 Fan System Operation

Description: Operating schedule of fan systems are in Tables 2-4 through 2-7. Fan systems shall operate continuously (turned on) during scheduled operation hours for all occupancy types **except** for the residential units of high-rise residential buildings and hotel/motel guest rooms. In these occupancies, the user may model the fan operation either as *continuous* or *intermittent*. For continuous fan operation, the fan operates during scheduled operation hours regardless of whether heating or cooling is needed. For intermittent fan operation, the fan operates only when heating or cooling is needed. The DOE-2 Keyword for intermittent fan operation is:

INDOOR-FAN-MODE = INTERMITTENT

The DOE-2 Keyword for continuous fan operation is:

INDOOR-FAN-MODE = CONTINUOUS

DOE Keyword: FAN-SCHEDULE
INDOOR-FAN-MODE
NIGHT-CYCLE-CONTROL

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall model the fan operation as *continuous* for all occupancy types during scheduled operation hours except for the residential units of high-rise residential buildings and hotel/motel guest rooms. For these occupancies, ACMs shall accept input for the type of fan operation (*continuous* or *intermittent)*.

Default: INDOOR-FAN-MODE = CONTINUOUS

Modeling Rules for Reference Design (All): Standard design fan system operation shall be identical to the proposed design except when the user specifies electric resistance heating without a fan system for residential units of high-rise residential buildings and hotel/motel guest rooms. In such cases the reference design fan operation shall be *intermittent*.

2.4.2.21 Fan Volume Control

Description: ACMs must be capable of modeling the electrical input ratio, EIR, of supply and return fans for systems 3 and 4 as a function of the part-load-ratio (the ratio of supply air rate at any given time to the supply air rate at design maximum conditions). All ACMs that explicitly model variable air volume HVAC systems must require the user to input the type of fan volume control for each supply/return fan combination of the proposed. Minimum required fan volume controls and associated part-load-curves are given below in the form of DOE 2.1 curve-fit instructions.

- *Constant volume*. Fan supplies a constant volume of air at constant power draw whenever it is in operation. This system does not have a part-load-curve.

- *Forward curved centrifugal fan with discharge dampers*. Variable volume fan with static pressure control dampers at the fan outlet or with no direct static pressure control.

```
FC-FAN-W/DAMPERS = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.22
DATA =          (.0,1.0)
                  (0.9,0.88)
                  (0.8,0.75)
                  (0.7,0.66)
                  (0.6,0.55)
                  (0.5,0.47)
                  (0.4,0.40)
                  (0.3,0.33)
                  (0.2,0.27)  ..
```

- *Forward curved centrifugal fan with inlet vanes*. Variable volume fan with static pressure flow controlled by vanes at the fan inlet.

```
FC-FAN-W/VANES = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.22
DATA =          (1.0,1.0)
                  (0.9,0.78)
                  (0.8,0.60)
                  (0.7,0.48)
                  (0.6,0.38)
                  (0.5,0.29)
                  (0.4,0.24)
                  (0.3,0.23)
                  (0.2,0.22)  ..
```

- *Air foil centrifugal fan with inlet vanes.* Fan is controlled by variable inlet vanes.

```
AF-FAN-W/VANES = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.48
DATA =          (1.0,1.0)
                  (0.9,0.83)
                  (0.8,0.71)
                  (0.7,0.66)
                  (0.6,0.60)
                  (0.5,0.55)
                  (0.4,0.52)
```

(0.3,0.48) ..

- *Variable speed drive*. Variable volume fan of any type with static pressure control by an AC frequency invertor varying fan speed.

  ANY-FAN-W/VSD = CURVE-FIT
  TYPE = QUADRATIC
  OUTPUT-MIN = 0.10
  DATA = (1.0,1.0)
  (0.9,0.78)
  (0.8,0.57)
  (0.7,0.40)
  (0.6,0.29)
  (0.5,0.20)
  (0.4,0.15)
  (0.3,0.11)
  (0.2,0.10) ..

DOE Keyword: FAN-CONTROL

Input Type: Prescribed

Tradeoffs: N/A

Modeling Rules for Proposed Design: The ACM shall model the same fan volume control for proposed systems as documented in the plans and specifications for the building. The user may not enter part-load curves for fans or other HVAC equipment.

Modeling Rules for Reference Design (New): ACMs shall assume a *variable speed drive* for fan volume control for each proposed fan in standard design systems 3 and 4 when the fan motor is greater than 25 horsepower. For systems 1, 2, and 5, ACMs shall assume the same fan volume control as the proposed design.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall use the existing fan volume control for the reference design.

2.4.2.22 Design Fan Power Demand

Description: ACMs must model the fan system power demand for all fans in the system that are required to operate at *design* conditions in order to supply air from the source to the conditioned space and to return it back to the source or to exhaust it to outdoors. The reference program models the fan system power demand using Fan Power Index (FPI). Fan power index is defined as the hourly power consumption of the fan system per unit of air moved (Watts per cfm).

For each supply fan and each return fan system (except for the fan-coil system serving the residential unit of a high-rise residential building or a hotel/motel guest room), ACMs must require the user to input: 1) the design BHP; 2) the design drive motor efficiency; and, 3) the design motor efficiency, all at peak design air flow rates. Exhaust fans that are manually controlled (such as bathroom fans) may not operate at design conditions and therefore must **not** be included in the fan system power demand calculations.

The reference method calculates the FPI for each fan system according to the following equation:

$$FPI = \frac{746}{CFM_s}\left[\frac{BHP_s}{\eta_{ds} \times \eta_{ms}} + \frac{BHP_r}{\eta_{dr} \times \eta_{mr}}\right]$$

where:

FPI	=	fan power index, [watts/cfm]
CFM_S	=	peak supply air flow rate, [ft^3/min]
BHP_S	=	brake horsepower of supply fan at CFM_S [hp]
η_{ds}	=	supply drive efficiency [unitless]
η_{ms}	=	supply motor efficiency [unitless]
BHP_r	=	brake horsepower of return fan at CFM_S [hp]
η_{dr}	=	return drive efficiency [unitless]
η_{mr}	=	return motor efficiency [unitless]

If the user does not input the design brake horsepower (BHP) and the peak supply air flow rate (cfm) for forced air systems, the ACM shall assume that no mechanical compliance will be performed and shall model the default mechanical system according to the rules in Section 2.4.2.26 (modeling default heating and cooling systems).

DOE Keyword: SUPPLY-KW
SUPPLY-DELTA-T
RETURN-KW
RETURN-DELTA-T

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: All ACMs must model proposed system fan power as documented in the plans and specifications for the building. The proposed design shall use the fan motor efficiency established in accordance with NEMA Standard MG1.

Modeling Rules for Reference Design (New): The reference method determines the standard design fan power as follows:

a) For systems 1, 2, and 5 with proposed FPI ≤ 0.80: The standard design FPI shall be the same as the proposed design.

b) For systems 1, 2 and 5 and proposed FPI > 0.80: The standard design FPI shall be 0.80.

c) For systems 3 and 4 and proposed FPI ≤ 1.25: The standard design FPI shall be the same as the proposed design.

d) For systems 3 and 4 and proposed FPI > 1.25: The standard design FPI shall be 1.25.

ACMs shall use the same BHP, peak supply flow rate, and drive efficiency as the proposed design. The reference method shall use the appropriate minimum nominal full-load motor efficiency from Table 2-8.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): All ACMs must model the existing system fan power according to the specifications of the existing system. The reference method shall use the full-load nominal efficiency of the existing motor as established in accordance with NEMA Standard MG1. If the efficiency of the existing motor is not available, ACMs shall use the appropriate minimum nominal full-load motor efficiency from Table 2-8.

2.4.2.23 Process Fan Power

Description: Portion of the total fan power exclusively used for air treatment or filtering systems. For each fan system used for air treatment or filtering, ACMs must adjust the fan power index according to the following equation:

$$\text{Adjusted Fan Power Index (FPI)} = \text{Total FPI} \times (1- SP_a/SP_f)$$

where:

SP_a = Air pressure drop across air treatment or filtering system, and
SP_f = Total pressure drop across the fan system

Fans whose fan power exclusively serve as process fans must not be modeled for simulation.

2.4.2.24 Air Economizers

Description: The reference method is capable of simulating an economizer that: (1) modulates outside air and return rates to supply up to 100% of design supply air quantity as outside air; and, (2) modulates to a fixed position at which the minimum ventilation air is supplied when the economizer is not in operation.

The reference method will simulate at least two types of economizers and all ACMs must receive input for these two types of economizers:

1. *Integrated*. The economizer is capable of providing partial cooling, even when additional mechanical cooling is required to meet the remainder of the cooling load. The economizer is shut off when outside air temperature or enthalpy is greater than a fixed setpoint.

2. *Nonintegrated/fixed set point*. This strategy allows only the economizer to operate below a fixed outside air temperature set point. Above that set point, only the compressor can provide cooling.

DOE Keyword: ECONO-LIMIT
ECONO-LOCKOUT
ECONO-LOW-LIMIT

Input Type: Default

Tradeoffs: Yes

Modeling Rules for The ACM shall allow the user to input either an *integrated* or *non-integrated*

Proposed Design: economizer as described above as it occurs in the construction documents. The ACM shall require the user to input the ODB set point.

Default: No Economizer

Modeling Rules for Reference Design (New): The standard design shall assume an *integrated* air economizer, available for cooling any time ODB < ~~75~~T_{limit}, on systems 1, 2, 3 and 4 (See ***Standard Design Systems Types***) when mechanical cooling output capacity of the proposed design as modeled in the compliance run by the ACM is over 75,000 Btu/hr and fan system volumetric capacity of the proposed design as modeled in the compliance run by the ACM is over 2500 cfm. T_{limit} shall be set to 75°F for climate zones 1, 2, 3, 5, 11, 13, 14, 15 & 16. T_{limit} shall be set to 70°F for climate zones 4, 6, 7, 8, 9, 10 & 12. The ACM shall not assume economizers on any system serving high-rise residential and hotel/motel guest room occupancies.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): All ACMs must model existing economizers as they occur in the existing building.

2.4.2.25 Sizing Requirements

Description: ACMs must determine outdoor weather design conditions from the user entry for building location which in turn is selected from a list of cities. The Commission can provide software for city selection which is linked to a database of outdoor design conditions. The outdoor design data determined from the building location is used for calculating design heating and cooling loads. In certain rural locations the user may enter a building location that is not the closest city with the explicit approval of the local enforcement agency. The same city must appear for all reports of building location and design weather data. The indoor design air temperature is based on the occupancy type using Table 2-4, 2-5, 2-6, or 2-7.

ACMs must perform design heating and cooling load calculations for each zone of the standard and proposed buildings. The design load methodology must be consistent with the ASHRAE Handbook, 1997, Fundamentals Volume, or with another method approved by the Executive Director.

The reference method uses the following assumptions for design loads:

- ***Fixed design assumptions by occupancy as listed in Tables 2-1 or 2-2.*** Different occupancy schedules are used by the reference method to determine design loads. For cooling loads, lights, equipment/receptacles, and people are at 100% of full load while the building is occupied. For heating loads, these internal gains are 0% of full load at all hours of the day. The HVAC equipment operational hours and thermostat settings schedules must be based on the selected occupancy type using the occupancy schedules shown in Table 2-4, 2-5, 2-6, or 2-7.

- ***Ventilation and process loads.*** See applicable sections on *ventilation and process loads.*

- ***Outdoor design temperatures for the building site location from ASHRAE publication SPCDX****: Climate Data for Region X, Arizona, California, Hawaii and Nevada, 1982*; latitude of building site location.

- ***Design temperatures, summer daily temperature swing and latitude***. The ACM user must either be able to select a city from a list which automatically retrieves the ASHRAE Region X Winter Median of Extremes temperature; and the Summer Dry-Bulb (0.5%) and Mean Coincident Wet-Bulb temperatures for the building site from a database; or the user must be able to enter the values mentioned above directly into the ACM. The ACM user must also enter the daily temperature range for the design cooling day and the latitude or have this value determined by city selection.

ACMs must calculate, for both the standard and proposed designs, heating and cooling loads and appropriate capacities for supply fans, cooling and heating equipment, hydronic pumps and heat rejection equipment as appropriate for the five standard design systems. All assumptions for heating and cooling equipment and fan system sizing are documented below.

2.4.2.25.1 Cooling Loads

Description: The reference method calculates cooling loads for each fan system using the following assumptions:

- Peak cooling design day profiles developed from *ASHRAE SPCDX: Climate Data for Region X, Arizona, California, Hawaii and Nevada, 1982* design weather data for the city in which the building will be built. These profiles must be developed using a method similar to the design day method of the reference computer program.

- All window interior and user-operated shading devices are ignored.

- Internal gains from occupants and receptacle loads are fixed at 100% of the values listed in Tables 2-1 or 2-2 while the building is occupied.

- Indoor dry-bulb temperatures are specified according to Tables 2-4, 2-5, 2-6, or 2-7, however, the ACM must be able to calculate the indoor wet-bulb temperature using the occupancy information and the cooling coil characteristics.

- Outdoor design temperatures equal to those listed in the Summer Design Dry Bulb 0.5% and the Summer Design Wet-Bulb 0.5% columns of ASHRAE publication SPCDX are used. For cooling tower design, temperatures listed in the Summer Design Wet-Bulb 0.5% columns must be used.

Modeling Rules for Proposed Design: The reference method calculates the proposed design cooling load using the same assumptions used by the mechanical system designer, including all proposed lighting, ventilation and process load at a constant 100% of the levels documented in the plans and specifications for the building. That is internal loads are all at 100% of full load for the duration of the cooling load calculation.

Modeling Rules for Reference Design (All): The reference method calculates the standard design load calculations with the following assumptions:

- Lighting levels fixed according to Table 2-1 or 2-2 unless *tailored lighting* documentation and forms are submitted and *tailored lighting* levels are input by the user, in which case the *tailored lighting* level is assumed. A non-zero *tailored lighting* input is an exceptional condition requiring approved or concurrently-submitted prescriptive lighting forms and documentation and special verification by the local enforcement agency.

- Ventilation levels fixed according to Tables 2-1 or 2-2 unless *tailored ventilation* rates are justified and input by the user, in which case the *tailored ventilation* level is assumed. A non-zero *tailored ventilation* input is an exceptional condition requiring written justification by the applicant and special verification by the local enforcement agency.

- Process loads are assumed to be zero unless the locations and types of the equipment producing the process energy are specified on the plans and specifications of the building. Process loads are an exceptional condition requiring written justification by the applicant and special verification by the local enforcement agency.

2.4.2.25.2 Heating Loads

Description: The reference method calculates heating loads for each fan system using the following assumptions:

- Indoor design temperatures according to Tables 2-5 or 2-6.

- No direct solar heat gains.

- All internal gains -- occupants, receptacle loads, other loads (such as pickup load) and lighting levels shall be assumed to be 0% of user input, default and fixed values.

- Indoor design temperatures according to Tables 2-5 or 2-6.

- Outdoor design temperatures equal to those listed in the Winter Median of Extremes column of ASHRAE publication SPCDX: Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, 1982.

2.4.2.25.3 Sizing Procedure for Systems 1, 3, 4, and 5

Modeling Rules for Proposed Design:

1. Calculate proposed fan air flow requirements, cfm_{pc}, based on the design supply air temperature input by the user. The calculated proposed fan air flow requirement is the larger of the heating and cooling air flow requirements, but no lower than 0.4 cfm/sf overall.

Note: In the text that follows regarding the "design procedure" or "sizing procedure" subscripts are used for a variety of variables. In the first subscript position subscripts symbols mean:

p = proposed - for the proposed building or design
s = standard - for the standard or reference design

In the second subscript position subscript symbols are used:

c = calculation - for design calculation or sizing calculation
s = simulation - for the compliance simulation
i = input - for user input

In some instances, nom is added after the subscripts to indicate the nominal value of a variable requiring further adjustments.

For the sizing ratio, R, subscripts are used:

f = fans
c = cooling
h = heating

Calculate, R_f, the ratio of the actual proposed design fan air flow, cfm_{pi} and the calculated fan air flow requirement, cfm_{pc}, and determine the standard design fan sizing factor, F, and the proposed modeled supply air flow rate, cfm_{ps}, as follows:

if $R_f \geq 1.3$	$F = 1.3$	$cfm_{ps} = cfm_{pi}$
if $1.0 < R_f < 1.3$	$F = R_f$	$cfm_{ps} = cfm_{pi}$
if $R_f \leq 1.0$	$F = 1.0$	$cfm_{ps} = cfm_{pc}$

Adjust all zone supply air rates and supply air rates for groups of zones according to the procedure described above.

2. Calculate system coil loads by adjusting the proposed design calculated cooling loads for fan heat and ventilation loads.

3. Reheat coil sizes are as input by the user for interior zones. Reheat with series for perimeter zones are as input by the user but no smaller than 120% of the peak heating load assuming minimum supply air temperature. All VAV minimum positions are as input by the user but no smaller than the minimum ventilation quantity.

4. Calculate total individual cooling plant loads, $CCAP_{pc}$, as the sum of all calculated coil loads served by individual plants (eg. direct expansion unit, chiller, etc.).

   Calculate, R_c, the ratio of the input proposed total plant cooling capacity, $CCAP_{pi}$, to the proposed calculated total cooling capacity, $CCAP_{pc}$, and determine the standard design cooling sizing factor, C, and the proposed nominal modeled total cooling capacity, $CCAP_{psnom}$, as follows:

if $R_c \geq 1.21$	$C = 1.21$	$CCAP_{psnom} = CCAP_{pi}$
if $1.0 < R_c < 1.21$	$C = R_c$	$CCAP_{psnom} = CCAP_{pi}$
if $R_c \leq 1.0$	$C = 1.0$	$CCAP_{psnom} = CCAP_{pc}$

$CCAP_{ps}$ is determined from $CCAP_{psnom}$ by adjusting for fan generated heat:

$$CCAP_{ps} = CCAP_{psnom} + 1.08(CFM_{ps} - CFM_{pc}) \times Fan\ T_p$$

5. Calculate individual heating plant loads, $HCAP_{pc}$, as the sum of all calculated coil loads served by individual plants (eg. boiler, furnace, etc.).

   a) For system 1, the calculated proposed system heating capacity, $HCAP_{pc}$ is the larger of the actual fan cfm x 25 and the calculated steady state heating. Calculate, R_h, the ratio of the input proposed plant heating capacity, $HCAP_{pi}$, to the proposed calculated heating capacity, $HCAP_{pc}$, and determine the standard design heating sizing factor, H, and the proposed modeled heating capacity, $HCAP_{ps}$, as follows:

if $R_h \geq 1.43$	$H = 1.43$	$HCAP_{ps} = HCAP_{pi}$
if $1.2 < R_h < 1.43$	$H = R_h$	$HCAP_{ps} = HCAP_{pi}$
if $R_h \leq 1.2$	$H = 1.2$	$HCAP_{ps} = 1.2 \times HCAP_{pc}$

   b) For systems 3, 4 and 5, calculate, R_h, the ratio of the input proposed plant heating capacity, $HCAP_{pi}$, to the input calculated heating capacity, $HCAP_{pc}$, and determine the standard design heating sizing factor, H, and the proposed modeled heating capacity, $HCAP_{ps}$, as follows:

if $R_h \geq 1.43$	$H = 1.43$	$HCAP_{ps} = HCAP_{pi}$
if $1.2 < R_h < 1.43$	$H = R_h$	$HCAP_{ps} = HCAP_{pi}$
if $R_h \leq 1.2$	$H = 1.2$	$HCAP_{ps} = 1.2 \times HCAP_{pc}$

Modeling Rules for Reference Design (All):

1. Load calculations are performed for the standard building. Total system fan supply air flows are calculated using the same supply air temperatures used for the proposed design, except limited to the ranges listed in the standard design system inputs in Figures 2-2a through 2-2d, and multiplied by the standard design sizing factor, F, determined in the proposed design sizing procedure.

2. Supply air quantities for each zone of multiple zone systems are determined by calculated zone loads, adjusted so that the block load adds up to the fan cfm.

3. Reheat coil sizes are determined with minimum VAV box positions of 0.8 for interior zones and 0.5 for perimeter zones on interior included reheat coils are only to the standard design if they have been input for the proposed design. Standard design VAV characteristics are determined as follows:

Air flow rates for interior zones (only those without exterior walls) are further oversized by 33%. Minimum VAV settings for interior VAV zones are set to meet the larger of minimum ventilation requirements, 0.4 cfm/sf or 30% of the zone peak supply air requirements. Reheat is added to meet ventilation loads only if input for the proposed design.

Minimum volume settings for exterior VAV zones are set to the larger of 0.4 cfm/sf or 30% of the zone peak supply air requirements.

4. Standard system coil loads are calculated based on calculated zone loads adjusted for fan heat and ventilation loads, then adjusted again for piping loads (for hydronic systems only). Standard system plant capacities are determined by multiplying adjusted coil loads by the standard design sizing factors, C and H, determined in the proposed design sizing procedure.

2.4.2.25.4 Sizing Procedure for System 2

Modeling Rules for Proposed Design:

1. Calculate proposed fan air flow requirements, cfm_{pc}, based on the design supply air temperature input by the user or the default supply air temperature listed in the system description in Figure 2-2a. The calculated proposed fan air flow requirement is the larger of the heating and cooling air flow requirements, but no lower than 0.4 cfm/sf overall.

   Calculate, R_f, the ratio of the actual proposed design fan air flow, cfm_{pi} and the calculated fan air flow requirement, cfm_{pc}, and determine the standard design fan sizing factor, F, and the proposed modeled supply air flow rate, cfm_{ps}, as follows:

if $R_f \geq 1.3$	$F = 1.3$	$cfm_{ps} = cfm_{pi}$
if $1.0 < R_f < 1.3$	$F = R_f$	$cfm_{ps} = cfm_{pi}$
if $R_f \leq 1.0$	$F = 1.0$	$cfm_{ps} = cfm_{pc}$

   Adjust all zone supply air rates and supply air rates for groups of zones according to the procedure described above.

2. Calculate system coil loads by adjusting the proposed design calculated cooling loads for fan heat and ventilation loads.

3. Calculate, R_c, the ratio of the input proposed plant cooling capacity, $CCAP_{pi}$, to the same calculated capacity, $CCAP_{pc}$, and determine the standard design cooling sizing factor, C, and the proposed modeled cooling capacity, $CCAP_{ps}$, as follows:

if $R_c \geq 1.21$	$C = 1.21$	$CCAP_{ps} = CCAP_{pi}$
if $1.0 < R_c < 1.21$	$C = R_c$	$CCAP_{ps} = CCAP_{pi}$
if $R_c \leq 1.0$	$C = 1.0$	$CCAP_{ps} = CCAP_{pc}$

4. Calculate the amount of electric resistance heat, $HCAP_{pelec}$, by comparing

the user input heating capacity at design conditions, $HCAP_{pdesign}$, to the actual heating load and using the following equations:

$$HCAP_{pdesign} = HP \times HCAP_{pi}$$
$$HLOAD_{pdesign} = HP \times HCAP_{sc}$$
$$HCAP_{pelec} = 1.43 \times HLOAD_{pdesign} - HCAP_{pdesign}$$

5. If the user does not input design heat pump heating capacity, calculate $HCAP_{elec}$ according to the following procedure:

   a) Calculate the heat pump design load factor, HP, from equation 2.4.11.

   b) Calculate $HCAP_{pdesign}$ by multiplying the rated heat pump heating capacity, input by the user, by HP.

   c) Use the equation under step 4 to calculate $HCAP_{elec}$.

Modeling Rules for Reference Design (All):

1. Load calculations are performed for the standard building. Total system fan supply air flows are calculated using the standard design cooling load and the same supply air temperatures used for the proposed design, except limited to the ranges listed in the standard design system inputs in Figure 2-2a, and multiplied by the standard design fan sizing factor, F, determined in the proposed design sizing procedure.

2. Standard system coil loads are calculated based on calculated zone loads adjusted for fan heat and ventilation loads. Standard system cooling capacity is determined by multiplying adjusted coil loads by the standard design cooling sizing factors, C, determined in Step 3 of the proposed design sizing procedure, unless Step 4 below applies.

3. Standard design heating capacity, $HCAP_{ss}$, is determined from the following procedure:

   a) $CCAP_{ss} = C \times (CCAP_{sc} + 1.08[CFMss\text{-}CFMsc] \times Fan\ \ T_s)$
   and

   $$SCAP_{ss} = C \times SCAP_{sc}$$

   $$HCAP_{ss} = CCAP_{ss}$$

   b) Calculate the heat pump design load factor, HP, from the following equation:

   $$HP = 0.25367141 + 0.01043512\,K + 0.00018606\,K^2 - 0.00000149\,K^3 \qquad \textbf{Equation 2.4.11}$$

   where

   $$K = T_{outside}$$

c) Calculate the design heating capacity, $HCAP_{sdesign}$, by multiplying the rated heat pump heating capacity, input by the user, by HP.

$$HCAP_{sdesign} = HP \times HCAP_{pi}$$

$$HLOAD_{sdesign} = HP \times HCAP_{sc}$$

d) $HCAP_{sdesign}$ is adjusted to be the larger of $HCAP_{sdesign}$, and 75% of the actual design heating load adjusted for fan power and ventilation loads, $HLOAD_{sdesign}$, or

$$HCAP_{sdesign} = \text{MAXIMUM} (HCAP_{sdesign}, 0.75 \times HLOAD_{sdesign})$$

e) The electric heating capacity for the standard design is thus determined:

$$HCAP_{selec} = 1.43 \times HLOAD_{sdesign} - HCAP_{sdesign}$$

f) If $HCAP_{sdesign}$ is determined from $0.75 \times HLOAD_{sdesign}$, then the modeled standard design heat pump heating capacity, $HCAP_{ss}$, is determined from the following equation:

$$HCAP_{ss} = HLOAD_{sdesign} / HP$$

$$CCAP_{ss} = HCAP_{ss}$$

2.4.2.26 Modeling Default Heating and Cooling Systems

Description: ACMs shall model the proper default heating and cooling systems when the user indicates, with the required ACM input, one of the following conditions for the building:

1. *Mechanical compliance not performed*. When the user indicates that no mechanical compliance will be performed, the ACM must automatically model the default heating and cooling systems identical to the standard systems defined in Section 2.4.2.4 (Standard Design Systems). The ACM shall require the user to provide the information needed to determine the proper default system type.

2. *Mechanical compliance performed with no heating installed*. When the user indicates that mechanical compliance will be performed, but the entire project or portions of the space have no installed heating or are heated by an existing heating system, the ACM must default to a heating system identical to the standard heating system defined in Section 2.4.2.4 (Standard Design Systems) for the space(s) with no installed heating or heated by an existing system. The ACM shall require the user to provide the information needed to determine the proper default system type.

3. *Mechanical compliance performed with no cooling installed*. When the user indicates with the required ACM input that mechanical compliance will be performed, but the entire project or portions of the space have no installed cooling or are cooled by an existing cooling system, the ACM must default to a cooling system identical to the standard cooling system defined in Section 2.4.2.4 (Standard Design Systems) for the space(s) with no installed cooling or cooled by an existing system. The ACM shall require the user to provide the information needed to determine the proper default system type.

The heating fuel source shall be fossil-fuel and the cooling source for residential and hotel/motel guest rooms shall be “other”.

DOE Keyword: SYSTEM-TYPE

Input Type: Prescribed

Tradeoffs: N/A

Modeling Rules for Proposed Design: The proposed design systems shall be determined as follows:

1. *Mechanical compliance not performed*. ACMs shall automatically size and model the default heating and cooling systems and adjust the heating by the standard design sizing factor of 1.2. ACMs shall select the proper mechanical system based on the building type and whether the permitted space is single zone (the conditioned floor area is less than 2500 ft^2) or multiple zone (the conditioned floor area is 2500 ft^2 or greater). See Section 4.3.3.1 (Thermal Zones) for guidelines for zoning a building. The heating fuel source shall be fossil-fuel and the cooling source for residential and hotel/motel guest rooms shall be “other”.

   ACMs **must** report the default heating and cooling energy use on PERF-1 and indicate that mechanical compliance was not performed. ACMs **must not** print any Mechanical forms.

2. *Mechanical compliance performed with no heating installed*. ACMs shall automatically size and model the default heating system for the entire project or portions of the space which have no installed heating or use an existing system and adjust the capacity by the standard design sizing factor of 1.2. ACMs shall select the type of heating system based on the building type and whether the permitted space is single zone or multiple zone. The heating fuel source shall be fossil-fuel and the cooling source for residential and hotel/motel guest rooms shall be “other”.

   ACMs **must** print all applicable mechanical forms and report the heating energy use for the entire project. ACMs **must** report “No Heating Installed” for zones with no installed heating system and for zones using the existing heating system.

3. *Mechanical compliance performed with no cooling installed*. ACMs shall automatically size and model the default cooling system for the entire project or portions of the space which have no installed cooling or use an existing cooling system. ACMs shall select the type of heating system based on the building type and whether the permitted space is single zone or multiple zone.

The heating fuel source shall be fossil-fuel and the cooling source for residential and hotel/motel guest rooms shall be "other".

ACMs **must** print all applicable mechanical forms and report the cooling energy use for the entire project. ACMs **must** report "No Cooling Installed" for zones with no installed cooling system and for zones using the existing cooling system.

Proposed design supply air rates and heating capacity shall be determined according to procedures in Section 2.4.2.25 (Sizing Requirements) for the appropriate system type. Fan power shall be determined using 0.365 watts per cfm of supply air rate for the cooling system. The rate of supply air (in cfm) must meet the building's minimum ventilation requirements.

For occupancies other than the residential units of high-rise residential buildings and hotel/motel guest rooms, this default proposed cooling system shall also have an integrated dry-bulb economizer as specified in this section, regardless of the capacity.

Modeling Rules for Reference Design (All): ACMs shall determine the reference design systems as follows:

1. *Mechanical compliance not performed*. ACMs shall automatically size and model the appropriate standard heating and cooling systems **for the entire project** using Section 2.4.2.4 (Standard Design Systems). ACMs shall use the standard design sizing factor of 1.2 for heating.

2. *Mechanical compliance performed with no heating installed*. ACMs shall automatically size and model the appropriate standard heating and cooling systems **for the entire project** using Section 2.4.2.4 (Standard Design Systems). ACMs must adjust the heating capacity by the standard design sizing factor of 1.2.

3. *Mechanical compliance performed with no cooling installed*. ACMs shall automatically size and model the appropriate standard heating and cooling systems **for the entire project** using Section 2.4.2.4 (Standard Design Systems).

Standard design supply air rates, heating, and cooling capacity shall be determined according to procedures in Section 2.4.2.25 (Sizing Requirements) for the appropriate system type. Fan power shall be determined using 0.365 watts per cfm of supply air rate for the cooling system. The rate of supply air (in cfm) must meet the building's minimum ventilation requirements.

For occupancies other than the residential units of high-rise residential buildings and hotel/motel guest rooms this default standard cooling system shall also have an integrated dry-bulb economizer as specified in this section, regardless of the HVAC system fan volume or cooling capacity.

2.4.2.27 System Supply Air Temperature Control

Description: ACMs must be capable of modeling two control strategies, or reset strategies, for supply air temperature for any system compared to standard design systems 3 and 4. ACMs must: (1) require the user to specify the control strategy used for controlling supply air temperature; and , (2) allow the user to enter the design cooling supply air temperature. Each of these strategies is described below.

- *Constant*. Cooling supply air temperature is controlled to a fixed set point whenever cooling is required.
- *Outdoor Air Reset*. Cooling supply air temperature resets upward during cool weather to reduce zone reheat losses. The ACM must require the user to enter the reset schedule.

NOTE: Modeling dual duct systems in the proposed design requires the user to enter the heating supply air temperature control strategy as well. Refer to the Optional Systems and Plant Capabilities.

DOE Keyword: HEAT-CONTROL
COOL-CONTROL
DAY-RESET-SCH

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The reference method determines the supply air temperature control of the proposed design as input by the user according to the plans and specifications for the building. ACMs shall use the following schedule for the outdoor air reset:

```
SUPP-AIR-SCH    = DAY-RESET-SCH
SUPPLY-HI       = [SUPPLY-LO + 5]
SUPPLY-LO  = [greater of SAT and 50]
OUTSIDE-HI = [SUPPLY-HI]
OUTSIDE-LO      = [SUPPLY-LO]  ..

SUPP-AIR-RESET = RESET-SCHEDULE THRU DEC 31,
      (ALL)     SUPP-AIR-SCH  ..
```

In the absence of the user input, ACMs shall use the Outdoor Air Reset control strategy for the proposed building.

Default: Outdoor Air Reset

Modeling Rules for Reference Design (All): The reference method shall use the same supply air temperature control strategy and schedule as the proposed design.

2.4.2.28 Zone Ventilation Air

Description: The reference method models mechanical supply of outdoor ventilation air as part of simulation of any fan system. The ventilation rate for a fan system is the sum of all ventilation requirements for all zones served by the same fan system.

ACMs must allow the user to: 1) enter the ventilation rate for each zone; and, 2) identify the user input ventilation rate as a *tailored ventilation* rate. When *tailored ventilation* rates are entered for <u>any</u> zone, an ACM shall output on compliance forms that *tailored ventilation* rates have been used for compliance and that a Tailored Ventilation worksheet, and the reasons for different ventilation rates, must be provided as part of the compliance documentation. Tailored ventilation inputs are designed to allow special HVAC applications to comply, but to be used they must correspond to specific needs and the particular design and the plans and specifications used to meet those needs.

The reference method determines the minimum building ventilation rate by summing the ventilation rates for all zones determined from Table 2-1 or Table 2-2 as well as zones with *justified tailored ventilation rates*, input by the user.

DOE Keyword: OUTSIDE-AIR-CFM
MIN-OUTSIDE-AIR

Input Type: Default

Tradeoffs: N/A

Modeling Rules for Proposed Design: The reference method determines the proposed design zone ventilation rate as follows:

1. If no ventilation rate has been entered by the user, the ACM shall use values from Table 2-1 or 2-2 for the applicable occupancy as the zone ventilation rate for the proposed design.

2. If the zone ventilation rate has been entered by the user, the ACM shall use this value as the zone ventilation rate for the proposed design.

This total must not be less than the minimum ventilation rate calculated above. **The ACM must default to the minimum ventilation rate if the proposed ventilation rate, input by the user, is less than the minimum ventilation rate.**

Default: Ventilation rates from Table 2-1 or 2-2.

Modeling Rules for Reference Design (All): The reference method determines the standard design zone ventilation rate as follows:

1. If no *tailored ventilation* rate has been entered, the ACM shall use values from Table 2-1 or 2-2 for the applicable occupancy as the zone ventilation rate for the standard design.

2. If a *tailored ventilation* rate has been entered, the ACM shall assume the tailored value as the zone ventilation rate for the standard design.

2.4.2.29 Zone Terminal Controls

Description: ACMs must be capable of modeling zone terminal controls with the following features:

- *Variable air volume (VAV).* Zone loads are met by varying amount of supply air to the zone.

- *Minimum box position*. The minimum supply air quantity of a VAV zone terminal control must be set as a fixed amount per conditioned square foot or as a percent of peak supply air.

- *(Re)heating Coil*. ACMs must be capable of modeling heating coils (hot water or electric) in zone terminal units. ACMs may allow users to choose whether or not to model heating coils.

- *Hydronic heating*. The ACM must be able to model hydronic (hot water) zone heating.

- *Electric Heating*. The ACM must be able to model electric resistance zone heating.

ACMs must require the user to specify the above criteria for any zone terminal controls of the proposed system.

DOE Keyword: MIN-CFM-RATIO
ZONE-HEAT-SOURCE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The reference method models any zone terminal controls for the proposed design as input by the user according to the plans and specifications for the building. **All ACMs that explicitly model variable air volume systems must not allow any minimum box position to be smaller than the air flow per square foot needed to meet the minimum occupancy ventilation rate.**

Modeling Rules for Reference Design (New & Altered Existing): For systems 3 and 4, the ACM must model zone terminal controls for the standard design with the following features:

- Variable volume cooling and fixed volume heating

- Minimum box position set equal to the larger of:

  (a) 30% of the peak supply volume for the zone; or
  (b) The air flow needed to meet the minimum zone ventilation rate; or
  (c) 0.4 cfm per square foot of conditioned floor area of the zone.

- Hydronic heating.

Modeling Rules for Reference Design (Existing Unchanged): The reference method models any zone terminal control for the existing design as it occurs in the existing system.

2.4.2.30 Pump Energy

Description: The reference method models energy use of pumping systems for hot water, chilled water and condenser water systems (cooling towers), accounting for energy use of pumps and additional cooling energy associated with pump energy rejected to the water stream.

DOE Keyword: CCIRC-MOTOR-EFF
CCIRC-IMPELLER-EFF
CCIRC-HEAD
CCIRC-DESIGN-T-DROP
HCIRC-MOTOR-EFF
HCIRC-IMPELLER-EFF
HCIRC-HEAD
HCIRC-DESIGN-T-DROP
TWR-MOTOR-EFF
TWR-IMPELLER-EFF
TWR-PUMP-HEAD
TWR-RANGE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The reference method calculates proposed design pump energy using the following inputs and procedures:

- Hot Water Circulation Loop Pump

  a) Impeller Efficiency — 67%
  b) Motor Efficiency — Full-load efficiency of the electric motor established in accordance with NEMA Standard MG1 (see Section 2.4.2.17)

$$HCIRC-MOTOR-EFF=\frac{\sum_{i=1}^{n}(MEFF_{hwp\_i}\times HP_{hwp\_i})}{\sum_{i=1}^{n}HP_{hwp\_i}}$$

  where

  $MEFF_{hwp\_i}$ = Hot water pump motor efficiency
  HP_{hwp_i} = Hot water pump motor nameplate HP
  n = Number of hot water pump motors

  c) Motor Horsepower — As Designed
  d) Flow Rate — As Designed (in GPM)
  e) Temperature Drop — =Design Boiler Capacity (Btu)/(500×GPM) (in ^{o}F)
  f) Design Head — As Designed with a maximum of 100 feet of water.
  g) Pump Control — As Designed

- Chilled Water Circulation Loop Pump

a) Impeller Efficiency 72%

b) Motor Efficiency Full-load efficiency of the electric motor established in accordance with NEMA Standard MG1 (see Section 2.4.2.17)

$$CCIRC-MOTOR-EFF=\frac{\sum_{i=1}^{n}(MEFF_{chwp\_i}\times HP_{chwp\_i})}{\sum_{i=1}^{n}HP_{chwp\_i}}$$

where

$MEFF_{chwp\_i}$ = Chilled water pump motor efficiency
HP_{chwp_i} = Chilled water pump motor nameplate HP
n = Number of chilled water pump motors

c) Motor Horsepower As Designed

d) Flow Rate As Designed (in GPM)

e) Temperature Drop Calculated as follows (in ^{o}F)

$$CCIRC-DESIGN-T-DROP=\frac{\sum_{i=1}^{n}(Q_{des\_i})\times 12}{\sum_{i=1}^{n}(GPM_{evap\_i})\times 0.5}$$

where

Q_{des_i} = Chiller design capacity in tons
GPM_{evap_i} = Flow rate in the evaporator in GPM
n = Number of chillers

f) Design Temperature As Designed (in ^{o}F)

g) Design Head Minimum (100, $DH_{chwsyspiping}$) in feet of water

$$\Delta H_{chwsyspiping}=\Delta H_{chwsys}-\frac{\sum_{i=1}^{n}(GPM_{evap\_i}\times\Delta H_{evap\_i})}{\sum_{i=1}^{n}GPM_{evap\_i}}$$

where

$DH_{chwsyspiping}$ = Chilled water piping system head
DH_{chwsys} = Chilled water system head
GPM_{evap_i} = Evaporator flow (in GPM)
DH_{evap_i} = Evaporator bundle pressure drop (in feet of water)

n = Number of evaporators in the system

h) Pump Control — As Designed

- Condenser Water Circulation Loop Pump

a) Impeller Efficiency — 67%
b) Motor Efficiency — Full-load efficiency of the electric motor established in accordance with NEMA Standard MG1 (see Section 2.4.2.17)

$$TWR-MOTOR-EFF=\frac{\sum_{i=1}^{n}(MEFF_{cwp\_i}\times HP_{cwp\_i})}{\sum_{i=1}^{n}HP_{cwp\_i}}$$

where

$MEFF_{cwp\_i}$ = Condenser water pump motor efficiency
HP_{cwp_i} = Condenser water pump motor nameplate HP
n = Number of condenser water pump motors

c) Motor Horsepower — As Designed
d) Flow Rate — As Designed (in GPM)
e) Range — As Designed (in ^{o}F)
f) Design Head — Minimum(80, ΔH_{cws}) in feet of water

$$\Delta H_{cws}=\Delta H_{cwsys}+\frac{\sum_{i=1}^{n}(GPM_{evap\_i}\times\Delta H_{evap\_i})}{\sum_{i=1}^{m}GPM_{cond\_i}}$$

where

ΔH_{cwsys} = Condenser water system head
ΔH_{evap_i} = Evaporator bundle pressure drop (in feet of water)
ΔH_{cws} = Proposed Condenser water system head
GPM_{evap_i} = Evaporator flow (in GPM)
GPM_{cond_i} = Condenser flow (in GPM)
n = Number of evaporators in the system
m = Number of condensers in the system

g) Cooling Tower Height As Designed
h) Pump Control — As Designed

Modeling Rules for Reference Design (New): The reference method calculates standard design pump energy using the following inputs and procedures:

- Hot Water Circulation Loop Pump

a)	Impeller Efficiency	67%
b)	Motor Efficiency	Standard Motor Efficiency from Table 2-8
c)	Motor Horsepower	Same as the proposed design
d)	Flow Rate (in GPM)	Calculated from Standard Boiler Capacity = Boiler Capacity / 15000
e)	Temperature Drop	30 ^oF
f)	Standard Head	Same as proposed up to 100 feet of water
g)	Pump Control	Fixed Speed

- Chilled Water Circulation Loop Pump

a)	Impeller Efficiency	72%
b)	Motor Efficiency	Standard Motor Efficiency from Table 2-8
c)	Motor Horsepower	Same as the proposed design
d)	Flow Rate (in GPM)	Calculated from Standard Chiller Capacity GPM = tons $\times$ 2.0
e)	Temperature Drop	12 ^oF
f)	Design Temperature	44 ^oF
g)	Standard Head	Same as proposed design up to 100 feet of water
h)	Pump Control	Fixed Speed

- Condenser Water Circulation Loop Pump

a)	Impeller Efficiency	67%
b)	Motor Efficiency	Standard Motor Efficiency from Table 2-8
c)	Motor Horsepower	Same as the proposed design
d)	Range	10 ^oF
e)	Flow Rate (in GPM)	Calculated from Standard Chiller Capacity GPM = tons $\times$ (1 + 1/COP) $\times$ 2.4
f)	Standard Head	Minimum (80 , ΔH_{cws}) in feet of water

$$\Delta H_{cws} = \frac{\Delta H_{cwsyspiping}}{Multiplier} + 20 + \frac{\sum_{i=1}^{n}(GPM_{evap\_i} \times 20)}{\sum_{i=1}^{m} GPM_{cond\_i}}$$

where

$$\Delta H_{cwsyspiping} = \Delta H_{cwsys} - \frac{\sum_{i=1}^{m}(GPM_{cond\_i} \times \Delta H_{cond\_i})}{\sum_{i=1}^{m} GPM_{cond\_i}}$$

$\Delta H_{cwsyspiping}$	= Condenser water piping system head
ΔH_{cwsys}	= Condenser water system head
ΔH_{cond_i}	= Condenser bundle pressure drop (in feet of water)
ΔH_{cws}	= Standard Condenser water system head
GPM_{evap_i}	= Evaporator flow (in GPM)

GPM_{cond_i} = Condenser flow (in GPM)
Multiplier = A multiplier From Table 2-9 for adjusting the condenser water piping system head based on pipe size and flow at connection to the cooling tower.
n = Number of evaporators in the system
m = Number of condensers in the system

g) Pump Control Fixed Speed

Table 2-9: Pipe Head Multipliers Based on Pipe Size and Flow at Connection to the Cooling Tower

Proposed Flow		***Normal Size***		***Undersize down to***		***Oversized up to***	
From (GPM)	***To (GPM)***	***Pipe Size (inch)***	***Multiplier***	***Pipe Size (inch)***	***Multiplier***	***Pipe Size (inch)***	***Multiplier***
1	35	1.50	1.00	1.25	2.00	2.00	0.31
36	74	2.00	1.00	1.50	3.00	2.50	0.38
75	107	2.50	1.00	2.00	2.25	3.00	0.35
108	180	3.00	1.00	2.50	2.75	4.00	0.25
181	355	4.00	1.00	3.00	3.75	5.00	0.30
356	580	5.00	1.00	4.00	3.00	6.00	0.38
581	880	6.00	1.00	5.00	2.50	8.00	0.25
881	1,600	8.00	1.00	6.00	3.75	10.00	0.30
1,601	2,500	10.00	1.00	8.00	3.00	12.00	0.38
2,501	3,700	12.00	1.00	10.00	2.25	14.00	0.63
3,701	4,500	14.00	1.00	12.00	1.50	16.00	0.50
4,501	6,500	16.00	1.00	14.00	1.88	18.00	0.55
6,501	9,000	18.00	1.00	16.00	1.75	20.00	0.53
9,001	12,000	20.00	1.00	18.00	1.75	24.00	0.43
12,001	16,000	24.00	1.00	20.00	1.75	30.00	0.50
16,001	20,000	30.00	1.00	24.00	1.75	36.00	0.50
20,001	30,000	36.00	1.00	30.00	1.75	N/A	1.0
30,001	>30,001	Any Size	1.00	N/A	1.0	N/A	1.0

Default: Hot water loop design head = 75 feet of water
Chilled water loop design head = 75 feet of water
Condenser water loop design head = 60 feet of water

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACM shall use the information from the existing pumping systems for the reference design. If these information are not available, ACMs shall use the above Standard Design values.

2.4.2.31 Chiller Characteristics

Description: The ACM chiller model must, at a minimum, incorporate the following characteristics:

- *Minimum Ratio:* The minimum capacity for a chiller below which it cycles.
- *Electrical Input Ratio:* Efficiency of the chiller at rated conditions. It is the ratio of the electrical power input to the chiller to the nominal capacity of the chiller.
- *Condenser Type:* It specifies whether the condenser is air-cooled or water-cooled.
- *GPM perTon:* The ratio of cooling tower water flow in GPM to chiller capacity in tons.

DOE Keyword: MIN-RATIO
EIR
*-COND-TYPE
COMP-TO-TWR-WTR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model chiller characteristics as follows:

- ***Minimum Ratio:*** For chillers with customized curves, ACMs shall calculate the *minimum ratio* using the part-load data by

$$MIN - RATIO = \frac{Q_{des\_i}}{\text{Minimum}\left(\left[\mathrm{Q}_{\mathrm{pload\_i1}}, \mathrm{Q}_{\mathrm{pload\_i2}}, \ldots, \mathrm{Q}_{\mathrm{pload\_ij}}\right]\right)}$$

where

Q_{pload_ij} = Chiller part-load performance data, Capacity in tons
Q_{des_i} = Chiller design capacity (in tons)

The default *minimum ratio* values are shown in the Table below.

Chiller Type	Default Unloading Ratio
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

- ***Electrical Input Ratio***: ACMs shall calculate the Electrical Input Ratio (EIR) for chillers with customized performance curves from the user input data.

$$E - I - R = \frac{P_{des\_i} \times 3.413}{Q_{des\_i} \times 12.0}$$

where

P_{des_i}	= Chiller design input power (in kW)
Q_{des_i}	= Chiller design capacity (in tons)

For other chillers, ACMs shall calculate the EIR using

$$E - I - R = \frac{1}{COP}$$

where

COP = Coefficient of Performance

- ***Condenser Type:*** ACMs shall require the user to input whether the chiller is air-cooled or water-cooled.

- ***GPM per Ton:*** For water-cooled chillers with customized performance curves, ACMs shall determine the condenser water flow as a ratio of condenser water flow rate (GPM) to rated chiller capacity (tons) using the following equation.

$$COMP - TO - TWR - WTR = \frac{\sum_{i=1}^{n} GPM_{cond\_i}}{\sum_{i=1}^{m} Q_{des\_i}}$$

where

GPM_{cond_i}	= Condenser flow rate (in GPM)
Q_{des_i}	= Chiller design capacity (in tons)
n	= Number of condensers
m	= Number of chillers

For default water-cooled chillers, ACMs shall determine the condenser water flow as follows.

$$COMP - TO - TWR - WTR = \left[1 + \frac{1}{\frac{\sum_{i=1}^{n} (COP_i \times SIZE_i)}{\sum_{i=1}^{n} SIZE_i}} \right] \times 2.4$$

where

COP_i = Coefficient of performance for chiller i

$$SIZE_i = \frac{Q_{des\_i} \times 12{,}000}{1{,}000{,}000}$$

n = Number of chillers

Modeling Rules for Reference Design (New & Altered Existing):

ACMs shall model chiller characteristics for the reference design as follows:

- ***Minimum Ratio:*** ACMs shall calculate the *minimum ratio* default values are shown in the Table below.

Chiller Type	Default Unloading Ratio
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

- ***Electrical Input Ratio***: ACMs shall calculate the Electrical Input Ratio (EIR) for the reference design using

$$E - I - R = \frac{1}{COP}$$

where

COP = Coefficient of Performance

- ***Condenser Type:*** ACMs shall model water-cooled condenser for the reference design.

*-COND-TYPE = TOWER

- ***GPM per Ton:*** For water-cooled chillers with, ACMs shall determine the condenser water flow as follows.

$$COMP - TO - TWR - WTR = \left[1 + \frac{1}{\dfrac{\sum_{i=1}^{n}(COP_i \times SIZE_i)}{\sum_{i=1}^{n} SIZE_i}} \right] \times 2.4$$

where

COP_i = Coefficient of performance for chiller i

$$SIZE_i = \frac{Q_{des\_i} \times 12{,}000}{1{,}000{,}000}$$

n = Number of chillers

Modeling Rules for Reference Design (Existing Unchanged): ACMs shall model the existing chiller(s) using the actual data. If the actual data is not available, ACMs shall model the existing design the same as the reference design.

2.4.2.32 Number, Selection, and Staging of Chillers and Boilers

Description: The reference method accounts for staging of multiple cooling/heating units input for both the standard and proposed design.

DOE Keyword: INSTALLED-NUMBER
TYPE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model the number and staging of boilers and chillers as input and modeled by the user according to the plans and specifications for the building

Modeling Rules for Reference Design (New): The reference method selects the standard design chiller types as follows:

- Total cooling plant load < 150 tons: the standard system uses one (1) water-cooled scroll chiller.
- 150 tons ≤ total cooling plant load < 300 tons: the standard system uses one (1) water-cooled screw chiller.
- 300 tons ≤ total cooling plant load ≤ 600 tons: the standard system uses two (2) equally sized water-cooled centrifugal chillers.
- Total cooling plant load > 600 tons: the standard system uses a minimum of two (2) water-cooled centrifugal chillers but add machines as required to keep the maximum single unit size at or below 1000 tons.

ACMs shall bring up each chiller to 90 percent capacity prior to the staging of the next chiller. ACMs shall model the staged chillers in parallel.

The reference method selects the standard design boiler types as follows:

- Total heating plant load < 6,000,000 Btuh: the standard system uses one (1) atmospheric boiler (no combustion air fan).
- Total heating plant load ≥ 6,000,000 Btuh: the standard system uses two (2) atmospheric boilers (no combustion air fans) of equal size.

ACMs shall bring up each boiler to 90 percent capacity prior to the staging of the next boiler. ACMs shall model the staged boilers in parallel.

Modeling Rules for ACMs shall model the number and staging of boilers and chillers as input and

Reference Design (Existing Unchanged & Altered Existing): modeled by the user according to the existing design of the central heating and cooling plants.

2.4.2.33 Performance Curves for Electric Chillers

Description: The reference method models the performance curves of electric chillers as functions of variables such as the load, condenser water temperature, and flow rate.

The reference program uses a computer program to calculates custom regression constants for *electric chillers*. This program calculates the regression constants for performance curves according to the following rules, criteria, inputs, and outputs:

1. The curves are generated using ARI-550 or ARI-590 certified data.
2. The data have a minimum of 25 full-load points and 10 part-load points.
3. The full-load data represent a chilled water temperature range of (design-2) °F to (design+6) °F and a condenser water temperature range of 55°F to 85°F (or an outside dry-bulb temperature range of 45°F to 110°F for air-cooled equipment).
4. The part-load data represent unloading using both condenser relief and fixed design condenser temperature.
5. The rms error for power prediction on the data set is 5% or less.
6. The program report the APLV points as entered by the user and the chiller curve predicted performance at the same conditions.
7. The user cannot directly modify either the curve coefficients or the parameters including reference capacity, reference power, minimum unloading ratio, or maximum available capacity.

The program inputs are:

1. Make and model,
2. Chiller type,
3. Evaporator flow rate,
4. Evaporator bundle pressure drop,
5. Chiller design capacity,
6. Chiller design input power,
7. Chiller design chilled water supply temperature, and
8. Chiller design entering condenser water temperature (water-cooled), or
9. Chiller design outdoor dry-bulb temperature (air -cooled), and
10. Chiller APLV capacity,
11. Chiller APLV input power,
12. Chiller APLV chilled water supply temperature, and
13. Chiller APLV entering condenser water temperature (water-cooled), or
14. Chiller APLV outdoor dry-bulb temperature (air-cooled).

The program outputs are:

1. Predicted Coefficient Of Performance (COP) to within 5% of the

manufacturer's data,

2. Four predicted APLV points with a maximum rms error of 5 percent of the manufacturer's data, and
3. Regression coefficients.

For all of the chiller curves, there is a rated condition at which the curves are unity. These are a rated capacity and efficiency at full load and specific chilled water and condenser water supply temperatures. The default curves in DOE2.1E are all rated at 44°F chilled water supply temperature and 85°F condenser water supply temperature. These are the ARI 550-92 and 590-92 rating conditions. For custom curves these references will be $CHWS_{des\_i}$ and CWS_{des_i} (or OAT_{des_i} for air-cooled equipment).

Three curves are used to determine the performance of each chiller:

- EIR-FPLR — Percentage full-load power as a function of percentage full-load output.
- CAP-FT — Capacity correction factor as a function of chilled water supply temperature and condenser water supply temperature.
- EIR-FT — Efficiency correction factor as a function of chilled water supply temperature and condenser water supply temperature.

For air-cooled equipment the CAP-FT and EIR-FT curves are developed against the chilled water supply and outside air dry-bulb temperatures.

Each of the default curves are given in terms of regression constants (*a* through *f*). The regression equations have the following formats:

$$CAP\_FT = a + b \times CHWS + c \times CHWS^2 + d \times CWS + e \times CWS^2 + f \times CHWS \times CWS$$

$$EIR\_FT = a + b \times CHWS + c \times CHWS^2 + d \times CWS + e \times CWS^2 + f \times CHWS \times CWS$$

$$PLR = \frac{Q}{Q_{des} \times CAP\_FT(CHWS_{des}, CWS_{des})}$$

$$EIR\_FPLR = a + b \times PLR + c \times PLR^2$$

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
Q	Present load on chiller (in tons)
Q_{des}	Chiller design capacity (in tons)
CHWS	Chiller chilled water supply temperature °F
CWS	Entering condenser water temperature °F
$CHWS_{des}$	Chiller design chilled water supply temperature °F
CWS_{des}	Design entering condenser water temperature °F

For air-cooled equipment OAT is used in place of CWS in the CAP_FT and EIR_FT equations, where OAT is the outdoor dry-bulb temperature.

DOE Keyword: CURVE-FIT

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The reference program uses a computer program with capabilities, calculation criteria, and input and output requirements as described above for producing regression constants for performance curves of electric chillers specified on the plans and specifications for the building.

Default: Same regression constants and performance curves as those used for the reference design.

Modeling Rules for Reference Design (All): ACMs shall use the regression constants in Tables 2-10 through 2-16 for the performance curves of electric chillers.

Table 2-10: Default Capacity Coefficients for Electric Air-Cooled Chillers

Coefficient	Scroll	Recip	Screw	Centrifugal
a	0.40070684	0.57617295	-0.09464899	N/A
b	0.01861548	0.02063133	0.03834070	N/A
c	0.00007199	0.00007769	-0.00009205	N/A
d	0.00177296	-0.00351183	0.00378007	N/A
e	-0.00002014	0.00000312	-0.00001375	N/A
f	-0.00008273	-0.00007865	-0.00015464	N/A

Table 2-11: Default Capacity Coefficients for Electric Water-Cooled Chillers

Coefficient	Scroll	Recip	Screw	Centrifugal
a	0.36131454	0.58531422	0.33269598	-0.29861976
b	0.01855477	0.01539593	0.00729116	0.02996076
c	0.00003011	0.00007296	-0.00049938	-0.00080125
d	0.00093592	-0.00212462	0.01598983	0.01736268
e	-0.00001518	-0.00000715	-0.00028254	-0.00032606
f	-0.00005481	-0.00004597	0.00052346	0.00063139

Table 2-12: Default Efficiency EIR-FT Coefficients for Air-Cooled Chillers

Coefficient	Scroll	Reciprocating	Screw	Centrifugal
a	0.99006553	0.66534403	0.13545636	N/A
b	-0.00584144	-0.01383821	0.02292946	N/A
c	0.00016454	0.00014736	-0.00016107	N/A
d	-0.00661136	0.00712808	-0.00235396	N/A
e	0.00016808	0.00004571	0.00012991	N/A
f	-0.00022501	-0.00010326	-0.00018685	N/A

Table 2-13: Default Efficiency EIR-FT Coefficients for Water-Cooled Chillers

Coefficient	Scroll	Reciprocating	Screw	Centrifugal
a	1.00121431	0.46140041	0.66625403	0.51777196
b	-0.01026981	-0.00882156	0.00068584	-0.00400363
c	0.00016703	0.00008223	0.00028498	0.00002028
d	-0.00128136	0.00926607	-0.00341677	0.00698793
e	0.00014613	0.00005722	0.00025484	0.00008290
f	-0.00021959	-0.00011594	-0.00048195	-0.00015467

Table 2-14: Default Efficiency EIR-FPLR Coefficients for Air-Cooled Chillers

Coefficient	Scroll	Recip	Screw	Centrifugal
a	0.06369119	0.11443742	0.03648722	N/A
b	0.58488832	0.54593340	0.73474298	N/A
c	0.35280274	0.34229861	0.21994748	N/A

Table 2-15: Default Efficiency EIR-FPLR Coefficients for Water-Cooled Chillers

Coefficient	Scroll	Recip	Screw	Centrifugal
a	0.04411957	0.08144133	0.33018833	0.17149273
b	0.64036703	0.41927141	0.23554291	0.58820208
c	0.31955532	0.49939604	0.46070828	0.23737257

2.4.2.34 Cooling Towers

Description: The ACM cooling tower model must, at a minimum, incorporate the following characteristics:

- *Open circuit:* Condenser water is cooled by evaporation by direct contact with ambient outdoor air stream.

- *Centrifugal fan:* A centrifugal fan provides ambient air flow across evaporative cooling media.

- *Staging of Tower Cells:* Capacity is varied by staging of tower cells.

- *Electrical input ratio:* The ratio of peak fan power to peak heat rejection capacity at rating conditions.

DOE Keyword: TYPE
INSTALLED-NUMBER
TWR-CELL-CTRL
TWR-CELL-MIN-GPM
MIN-RATIO
EIR
TWR-DESIGN-WETBULB
TWR-DESIGN-APPROACH
TWR-SETPT-T
TWR-CAP-CTRL

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model cooling towers as follows:

- ***Sizing.*** ACMs must autosize the cooling tower using the following parameters:

  1. Design Wet-Bulb Temperature using 0.5% design wet-bulb column of ASHRAE publication SPCDX: Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, 1982.

  2. Design Approach Temperature as input by the user according to the plans and specifications for the building.

  3. Number of Tower Cells as input by the user according to the plans and specifications for the building.

     If the number of cells is specified, then

     INSTALLED-NUMBER = # of cells input by the user

     If the number of cells is not specified, then

$$INSTALLED-NUMBER = \frac{\sum_{i=1}^{n} Q_{des\_i}}{1000}$$

     where:

     Q_{des_i} = Chiller design capacity (in tons)
     n = Number of chillers

- ***Staging of Tower Cells.*** ACMs shall have a control scheme to use the maximum number of cells possible and stage on as many cells as can be staged to keep the flow rate per cell above the minimum allowable.

- ***Fan Control.*** ACMs shall accept input by the user for the cooling tower fan control according to the plans and specifications for the building.

- ***Condenser Water Set-point Control.*** ACMs shall use a set-point temperature of 70 ^oF.

- ***Electrical Input Ratio.*** ACMs shall calculate the Electrical Input Ratio (EIR) as follows:

$$E - I - R = \frac{HP_{CT} \times 2.545}{\sum_{i=1}^{n} (Q_{des\_i} \times 12 + P_{des\_i} \times 3.413)}$$

where:

HP_{CT} = Cooling tower nameplate horsepower per cell
Q_{des_i} = Chiller design capacity (in tons)
P_{des_i} = Chiller design input power (in kW)
n = Number of chillers

Modeling Rules for Reference Design (New):

The reference method uses a single cooling tower with the following features for the standard design system:

- ***Sizing.*** ACMs must autosize the cooling tower using the following parameters:

  1. Design Wet-Bulb Temperature using 0.5% design wet-bulb column of ASHRAE publication SPCDX: Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, 1982.

  2. Design Approach Temperature of 10 ^oF.

  3. Number of Tower Cells equal to the proposed design. If the proposed design uses air-cooled chillers (no cooling towers), the number of Tower Cells shall be equal to the number of chillers in the reference design.

- ***Staging of Tower Cells.*** The reference design shall use a control scheme to use the maximum number of cells possible and stage on as many cells as can be staged to keep the flow rate per cell above 50 percent of maximum.

- ***Fan Control.*** The reference design shall use a two-speed fan control system.

  TWR-CAP-CTRL = TWO-SPEED-FAN

- ***Condenser Water Set-point Control.*** The reference design shall use the same set-point temperature as the proposed design.

- ***Electrical Input Ratio.*** The reference design shall use an EIR of 0.013.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing cooling tower(s) using the actual data. If the actual data is not available, ACMs shall model the existing design the same as the reference design.

2.4.2.35 HVAC Distribution Efficiency of Packaged Equipment

Description: ACMs shall be able to determine the efficiency of ducts in the unconditioned spaces between insulated ceilings and roofs.

ACMs shall require the user to enter the duct insulation R-value, the number of building stories, and whether or not the ducts will be sealed and tested for reduced duct leakage.
ACMs shall be able to reproduce the duct efficiencies in Appendix H

DOE Keyword: None. Duct efficiency divisors for COOLING-EIR, COOLING-EIR-SEER and HEATING-HIR will be calculated by means of the equations in Appendix G.

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall calculate the duct efficiency for the *Proposed Design* as specified in Appendix G based on the user inputs specified in this section. The ACM shall require the user to input duct R-value, the number of building stories and whether or not credit for reduced duct leakage will be claimed and tested.

Default: Duct R-value of 4.2 [h°F ft^2/Btu] and duct leakage of 22% of fan flow. Number of stories is defaulted to one (1).

Duct Sealing Caution Warning on PERF-1 if HVAC Distribution Efficiency Option is claimed. Warning must include minimum qualification criteria described in Appendix G, Section 4.3.4

Modeling Rules for Reference Design (New): The ACM shall calculate the duct efficiency for the *Reference Design* as specified in Appendix G based on the default values specified in this section. The Reference Design shall assume the default values for the duct efficiency inputs (Duct R-value = 4.2, Duct Leakage = 22%) except that the number of stories shall be the same as for the Proposed Design.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the same distribution system for the Reference Design as for the Proposed Design

2.5 Service Water Heating - Required Capabilities

ACMs must be capable of modeling service water heating systems for nonresidential and high-rise residential buildings. The service water heating system must be modeled if it is part of combined hydronic system that serves both space and service water heating demands. ACMs are required to model independent systems for only service water heating. ACMs must require the user to identify if service water heating is included in the performance compliance submittal. ACMs must also require the user to identify the type of service water heating systems as described below under *Nonresidential Service Water Heating* and *Residential Service Water Heating*

2.5.1 Nonresidential Service Water Heating

ACMs must be able to accept inputs to distinguish electric or gas water heating source energy and must either assume part-load performance curves for the types of water heaters allowed to be entered OR allow entry of an efficiency (some sort of annual or seasonal efficiency is preferred but a steady state efficiency is acceptable) for the water heating system. The ACM must be able to accept inputs from the user for a recirculating water heating system or an electrically traced (electric tape) water heating system.

The standard water heating system for either of these two systems is a water heating system with all hot water pipes insulated and a gas boiler with an efficiency of 80%. For hotels and high-rise residential buildings, the standard water heating system is a recirculating system.

Water heating shall be modeled using the hourly loads for each occupancy as shown in Tables 2-1 or 2-2, multiplied by the fraction of load in each hour shown in the water heating schedule in Tables 2-4, 2-5, 2-6, or 2-7. These loads shall be combined for each zone to develop a total building water heating load for each hour. Each water heater shall be assigned an individual load, and shall be modeled independent of other water heaters. The ACM shall convert electric energy to Btu/hr at the conversion rate of 10.239 Btu per watt-hour.

2.5.2 Energy Use of Water Heaters for Nonresidential Buildings and Residential Buildings with Combined Hydronic Systems

The hourly water heating energy use shall be determined from Equation 2.5.1.

$$WHEU_n = SRL \times F_{whpl(n)} \times DHWHIR \times HIRCOR \qquad \textbf{Equation 2.5.1}$$

Where:

$WHEU_n$ = Water heating energy use for the nth hour

$F_{whpl(n)}$ = Hourly load multiplier for the nth hour from Table 2-4, 2-5, 2-6, or 2-7
SRL = Standard Recovery Load in Btu/hr, derived from the loads per person shown in Table 2-1 or 2-2 for the occupancy served by the water heater. If a water heater may serve more than one occupancy, the load should be weighted by the number of square feet in each occupancy served by the water heater.

$DHWHIR$ = Heating input ratio of the water heater(s) which is equal to the inverse of the recovery efficiency (RE) or thermal efficiency (TE). The recovery efficiency for electric water heaters is 0.98.

$HIRCOR$ = Part-load correction factor

HIRCOR is determined from the following procedure, given in the form of a DOE 2.1 curve fit instruction:

DHW-HIR-FPLR = ACM-DHW-CRV ..
ACM-DHW-CRV = CURVE-FIT
TYPE = LINEAR
COEFFICIENTS = (DHW-A,DHW-B) ..

These commands yield an equation for HIRCOR of:

HIRCOR = (DHW-A) + (DHW-B) ´ PLR

Where:

$$DHW - A = \frac{STBY}{INPUT} \qquad \textbf{Equation 2.5.2}$$

$$DHW - B = \frac{(INPUT \times RE^{*}) - STBY}{SRL} \qquad \textbf{Equation 2.5.3}$$

* or Thermal Efficiency (*TE*)

PLR_n = Part-load ratio for the n[th] hour and must always be less than 1. PLR_n is calculated from the following equation:

$$PLR_n = \frac{SRL \times F_{whpl(n)}}{INPUT \times RE^{*}} \qquad \textbf{Equation 2.5.4}$$

* or Thermal Efficiency (*TE*)

INPUT = The input capacity of the water heater expressed in Btu/hr.

STBY = Hourly standby loss expressed in Btu/hr.

For storage type water heaters, not in the scope of Covered Consumer Products as defined in the Title 10 or the Code of Federal Regulations, Part 430;

STBY = 453.75 ´ S ´ VOL **Equation 2.5.5**

Where:

S = The standby loss fraction published in the Commission’s Directory of Certified Water Heaters,

VOL = The actual storage capacity of the water heater as published in the Commission’s Directory of Certified Water Heaters,

For storage type water heaters that are covered consumer products, the standby loss shall be calculated with the following equation.

$$STBY = \frac{1440.104 \times \left(\frac{1}{EF} - \frac{1}{RE\,*} \right)}{\left(1 - \frac{1701.941}{(INPUT \times RE\,*)} \right)}$$ **Equation 2.5.6**

* or Thermal Efficiency (*TE*)

Where:

EF = Energy Factor

For instantaneous water heaters that are not Covered Consumer Products,

STBY = PILOT

Where PILOT is the pilot light energy use in Btu/hr

Required inputs and standard and proposed design assumptions depend on the type of water heater and whether or not it is a DOE covered consumer product.

2.5.2.1 DOE Covered Water Heaters

Description: ACMs must require the user to enter fuel type (electricity or gas), input, volume, energy factor, recovery efficiency or thermal efficiency, and quantity for DOE covered storage-type water heaters.

DOE Keyword: DHW-TYPE
DHW-SIZE
DHW-EIR
DHW-EIR-FT
DHW-EIR-FPLR

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The proposed design shall assume fuel type, input, volume, energy factor, recovery efficiency or thermal efficiency, and quantity as input by the user and as shown in the construction document for the building.

Modeling Rules for Reference Design (All): The standard design shall assume fuel type, input, volume, recovery efficiency or thermal efficiency, and quantity identical to the proposed design. The standard design shall assume an energy factor, calculated as a function of the volume, according to equations found in either Section 111 or 113 of the Building Energy Efficiency Standards~~Table F-5 of the Appliance Efficiency Regulations, CEC Publication #P400-92-029, dated September 1992~~.

2.5.2.2 Water Heaters not Covered by DOE Appliance Standards

Description: ACMs must require the user to enter fuel type, input, volume, recovery efficiency or thermal efficiency, standby loss and quantity for all storage type water heaters that are not covered by DOE appliance standards.

DOE Keyword: DHW-TYPE
DHW-SIZE
DHW-HEAT-RATE
DHW-EIR
DHW-EIR-FT
DHW-EIR-FPLR
DHW-LOSS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The proposed design shall assume fuel type, input, volume, recovery efficiency or thermal efficiency, standby loss and quantity as input by the user and as shown on the construction documents for the building.

Modeling Rules for Reference Design (All): The standard design shall assume fuel type, input, volume and quantity that are identical to the proposed design. The standard design shall assume recovery efficiency or thermal efficiency and standby loss ~~according to~~ as specified in either Section 111 or 113 of the Building Energy Efficiency Standards~~the applicable minimum requirements of Title 24, Part 1.~~

2.5.2.3 Boilers

Description: If a boiler (or boilers) serve both space and service water heating systems, the ACM shall assign space heating and recovery loads to the boiler for both the standard and proposed designs. Boilers shall be simulated as described in Section 2.4.2.14 or 2.4.2.15, whichever is applicable.

2.5.2.4 Unfired Indirect Water Heaters (Storage Tanks)

Description: ACMs shall simulate jacket losses and effective recovery efficiency for unfired indirect water heaters and storage tanks. Jacket losses shall be calculated using the following equation:

$$JL = \frac{117.534VOL^{0.66} + 99.605VOL^{0.33} + 21.103}{REI} + 61.4$$

Equation 2.5.7

Where:

JL = Hourly jacket loss in Btu
VOL = Volume of indirect heater or storage tank in gallons
REI = R-value of exterior insulating wrap

The adjusted hourly recovery load seen by the primary water heating devices described above (e.g. water heater or boiler) shall be calculated according to Equation 2.5.8

$$PARL_n = \frac{SRL \times F_{whpl(n)} \times JL}{0.98}$$

Equation 2.5.8

Where:

$PARL_n$ = Adjusted recovery load seen by the primary water heating device for the n^{th} hour

DOE Keyword: DHW-LOSS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall assume indirect water heaters with volume and REI as input by the user and as shown in the construction documents for the building. ACMs must not allow the user to enter an REI of less than 12.

Modeling Rules for Reference Design (All): If an indirect water heater is input as part of the proposed design, that standard design shall assume an indirect heater with the same volume as the proposed design and REI of 12.

2.5.3 Residential Water Heating Calculation Methods

For high-rise residential buildings, ACMs shall calculate the energy consumption of the proposed water heating system(s) and the water heating energy budget in accordance with Section 151(b)(1) of the standards. Alternatively, users may show service water heating compliance using the prescriptive requirements of Section 151(f)(8~~9~~) of the standards.

2.6 Weather Data

The energy budget and compliance runs must use a form of the weather data in the Commission's official sixteen (16) climate zone hourly weather files. The reference method uses a form of this data that is adjusted for local ASHRAE design data extremes. These files are available from the Commission in the WYEC2 (Weather Year for Energy Calculations) format recognized by ASHRAE and in DOE 2.1E packed weather data format. The reference method computer program for adjusting the climate zone weather data for local ASHRAE design data is also available from the Commission. Temperatures in the WYEC2 files for the sixteen climate zones have been adjusted to the average means and extremes of the weather data of the reliable substations in each climate zone. See *Climate Zone Weather Data Analysis and Revision Project*, Final Consultant Report, CEC Publication # P400-92-004, for more detail.
The WYEC2 data may be adjusted for local conditions, condensed, statistically summarized or otherwise reduced, as long as:

(a) The weather data used to derive the simplified or reduced data is the Commission's official hourly weather data; and,

(b) The ACM program meets all of the certification tests using the reduced weather data.

Whatever weather data and/or weather data reduction methods are used, approval of the ACM for compliance purposes with the standards is contingent upon the fact that approved weather data will be used for all compliance runs. The Commission must be able to verify that the proper weather data is being used by building permit applicants.

The official weather data for energy compliance is available from the Commission in a form suitable for 3.5" high density IBM PC-formatted diskettes. There are 16 climate zones, each with an 8760 hourly records containing raw data on a variety of ambient conditions such as:

- Dry-bulb temperature
- Wet-bulb temperature
- Wind speed and direction
- Direct solar radiation
- Diffuse radiation

Each climate zone file includes the non-temperature data of a hypothetical city whose annual climate data has been judged representative of the construction locations within that zone. The values listed by climate zone for each climate zone in Table 2-16 must be used for any given climate zone if the ACM does not automatically make local city weather adjustments to the files.

As indicated above the reference method uses local city ASHRAE design data to adjust the climate zone weather data. These adjustments customize the temperature data, especially the extremes, to conform to the ASHRAE design data statistics for the city in question. This makes the energy calculations more realistic for energy compliance simulations. These adjustments are described in more detail in Appendix C.

Table 2-16: California Climate Zone Summary

Climate Zone	Latitude (Degree)	Longitude (Degree)	Elevation (Feet)
1	40.8	124.2	43
2	38.4	122.7	164
3	37.7	122.2	6
4	37.4	122.4	97
5	34.9	120.4	236
6	33.9	118.5	97
7	32.7	117.2	13
8	33.6	117.7	383
9	34.2	118.4	655
10	33.9	117.2	1543
11	40.2	122.2	342
12	38.5	121.5	17
13	36.8	119.7	328
14	35.7	117.7	2293
15	32.8	115.6	-30
16	41.3	122.3	3544

2.7 Required Standard Reports

All nonresidential ACMs must be able to automatically produce certain reports in a standard format that has been approved by the Commission, the sample forms in Appendix E of this manual meet this requirement when a building is determined to comply with the standards. These standard reports are required to enable building officials to quickly and accurately evaluate the results of the various ACMs with limited additional training. The required output forms are intended to be as similar as possible to the forms used in the prescriptive compliance approach so that those who are familiar with the prescriptive forms will easily be able to find information on the output from the performance approach. In fact, with the exception of the PERF-1 form, other forms are nearly duplicates of prescriptive forms or full page portions of the prescriptive forms. To allow the optional capabilities of Partial Compliance, Alterations, or automatic modeling of Additions Modeled with the Existing Building, there are distinct additional forms describing existing building components and systems that must be printed separately than the forms describing the altered or new building components and systems and must have **ALL** text in lowercase type.

In the sample form formats in Appendix E, the first pages (signature pages) of the prescriptive ENV-1, LTG-1, and MECH-1 certificates of compliance are consolidated on the first page of the PERF-1 form. The PERF-1 is the Certificate of Compliance for the performance approach and all three parts of the PERF-1 form (at least three pages) must be included as part of the plans. All forms with the term "Certificate of Compliance" in the header of the sample forms must be attached as part of the plans submittal. Typically the pages of these forms are adhered to a plan sheet and submitted with the plans. These forms are considered to be an integral part of the plans and are to be recorded in exactly the same manner as a set of plans and retained for the same period of time as official records of the plans.

An ACM must be able to print standard reports/compliance forms (formats approved by the Commission) when a modeled building design complies with the standards as described in the reference procedure. The purpose of compliance output is to facilitate enforcement of the standards by providing the local enforcement agency with the precise amount of information needed to accurately verify compliance with the energy efficiency standards and to verify conformity of the building design with the modeled or simulated building. Too much or too little information obstructs enforcement. Secondary or irrelevant information confuses the building official or wastes his time. On the other hand, a lack of relevant information may lead to enforcement errors or encourage cheating. To be approved for compliance use, an ACM cannot allow the user to directly select the compliance forms to be printed. Each ACM must determine the compliance output based on the user's input description of the building and the type of compliance run for the building.

In addition, **an ACM must not be able to print compliance form formats when a modeled proposed building design does not comply with the building standards** - i.e. when a proposed building design modeled by an approved ACM in accordance with the reference procedure has an estimated energy budget that exceeds the estimated energy budget of the standard building design, compliance forms must not be printed, displayed on screen, or written on disk. An ACM is only required to provide a minimum of diagnostic results for buildings that DO NOT COMPLY. This minimum information includes the energy use components of the energy budget in source kBtu per ft^2 per year and the total source energy use budget for both proposed and standard building designs and the compliance margin. An ACM may also provide other diagnostic output when a building fails to comply, but all diagnostic output must be so different from the compliance output (in format, layout, and content) that a reasonable person could not confuse diagnostic output with compliance output. Each page or display screen of noncompliance output must indicate: DIAGNOSTIC OUTPUT ONLY - NOT FOR COMPLIANCE USE. An ACM that has noncompliance output **MUST NOT** report runcodes, initiation times, or total page counts on noncompliance output or display. Similarly, noncompliance output **MUST NOT** use approved form headers or header information at the top of a page. Resemblance of noncompliance output to compliance forms is sufficient grounds for rejection of the ACM for use as a compliance computer program.

Compliance output is highly restricted in quantity and format. All non-default inputs **must** be reflected directly in the output. This can also be accomplished by changes in directly-related output values and the forms reflecting those changes **must** be printed when any compliance output forms are selected. Exceptional user entries or values outside of "normal" ranges must be printed and must be clearly flagged in the output so that the plan checker and field checker can and will readily note these user entries or values. Exceptional user entries include such entries as tailored lighting and modifications to certain default values specified herein. When the user enters such exceptional input in a compliance run, the ACM must automatically print the forms containing such user inputs. Exceptional conditions must be indicated on the PERF-1 form as part of the special conditions verification checklist for the plan checker and field inspector.

This verification list must command the attention of anyone reviewing the output and must be included with all performance compliance submittals even if no exceptional conditions are reported. In particular exceptional inputs **must** be reflected on the relevant ENV, MECH, or LTG forms **and** the PERF-1 Form and the forms showing these exceptional entries **must** be printed when any compliance output forms are selected. Typically exceptional conditions or use of non-default values require additional backup information to be submitted. This information may be attached to the compliance form output submittal or included as additional ACM printed information following the package of approved compliance forms.

For a compliance documentation run, the ACM must automatically determine the forms to be printed and the total number of pages (T) required to print those forms and must print exactly that number of pages and all ACM-determined forms. The determination of the total number of pages (T) must be made based on the user's description of the scope of compliance, the building characteristics, and the user's selection of a compliance run. ACMs may not allow the user to select specific forms to be printed in a compliance run (as distinguished from a diagnostic run) where printed or disk compliance output is requested. Each page (N) of the required output must indicate Page N of T in the page header, the unique compliance runcode and the initiation time of the compliance run. The PERF-1 must list or indicate all of the forms required for a valid submittal, including those required to be done by hand.

ACMs must interlock program input and compliance output to prevent any modifications to input files that is inconsistent with the compliance run and compliance output for the unmodified building input file. At a minimum, any alterations in the user input must result in a new run initiation time and runcode on any compliance output generated thereafter and a completely new full set of compliance output for the type of compliance selected must be printed when the ACM user has selected compliance output. In other words the compliance output is interlocked to a specific set of user input, this may be done by having a compliance runs use only information from a specific SAVED user input file or by having the ACM automatically save the input file as a part of the compliance run sequence. The ACM vendor is encouraged to restrict compliance output to be only generated from saved input files whose characteristics (size, creation date, and name) are indicated on the PERF-1 form.

User inputs must appear on the ACM reports but the reporting of prescribed input assumptions is usually unnecessary since ACMs are required to automatically use these inputs. The Commission does not want to encourage debate on prescribed assumptions at the local enforcement agency. Commission staff workshops and Commission hearings for changes to this manual are the appropriate forums for debating such ACM restrictions. ACMs are only allowed to report the prescribed inputs or assumptions that are required by the building official to verify compliance. When inputs with standard defaults are modified by the user, the modified value must be distinctly identified (flagged) in the standard reports to alert the local enforcement agency of an exceptional condition for compliance so that it can be verified by the code official that the alternate value is acceptable for compliance and corresponds to special features of the building documented in the plans and included as part of the building itself.

The format of the standard reports is designed to provide consistency with the prescriptive forms to reduce the amount of training required for the staff of local enforcement agencies. Consistency amongst the forms used for the prescriptive and performance approaches and amongst approved ACMs also fosters better and easier enforcement. Thus a standard format and style for reporting building energy efficiency compliance, reasonably consistent with the prescriptive forms in the Nonresidential Manual is required for all ACMs. However, minor modifications to the reports may be allowed in order to accommodate optional special modeling capabilities of an ACM. All additional reports and printed output information must be approved through the certification process.

To accommodate the optional capabilities of partial compliance and modeling additions with the existing building and alterations and deter circumvention of the standards, **all ACMs MUST report all new or altered user-entered building components and descriptive information completely in UPPERCASE type.** ACMs with the capabilities for partial compliance, automatic modeling of additions with the existing building or modeling alterations in an existing building **MUST report all information on existing, previously-approved building components that are not altered in lowercase type. For partial compliance the ACM must produce the special EXISTING-ENV forms for the existing envelope.** Partial compliance applicants with building envelopes approved within the previous two years must supply envelope compliance information along with the EXISTING-ENV forms. This is to insure that the local enforcement agency can readily determine that the existing envelope has indeed complied and that the use of existing building components that do not have to meet the requirements of the building energy efficiency standards and distinguish these modeled components from those that are new or have been altered.

The required reports shown in this section follow a format that can be reproduced with simple ASCII characters on any standard printer. The format is 75 characters per line and 60 lines per page. Using a standard 10-character-per-inch typeface (such as Courier), this format translates into a 0.5" margin top, bottom, left and right on letter-size (8.5"x11") paper.

2.7.1 Certificate of Compliance Form(s)

(PERF-1, ENV-1, EXISTING-ENV, LTG-1, EXISTING-LTG, MECH-1, and EXISTING-MEC)

The first standard report that must be produced by all ACMs is the Certificate of Compliance which is divided into four sections: the Performance Summary (PERF-1 forms), Envelope (ENV-1 form), lighting (LTG-1 form) and mechanical (MECH-1 forms). The Certificate of Compliance is required by Title 10, Section 1403(a)2.A, B and C(2) of the California Code of Regulations. For the performance approach all signature blocks for the Certificate of Compliance are combined onto the first page of the PERF-1 compliance output form. Normally all of these signature blocks must be signed by the responsible designers. However, when an ACM is approved for optional partial compliance features and the partial compliance option is being used, only one or two of the signature blocks need be filled in. However, when this occurs the signatures must be consistent with the type of partial compliance indicated on the Certificate of Compliance - PERF-1 forms and information reported on other output reports.

The PERF-1 must list all optional capabilities utilized by the user and must identify the zone(s), system(s) and/or plant(s) to which the optional capabilities apply. The PERF-1 must also itemize the use of any of the following exceptional building compliance features on the exceptional conditions checklist, identifying the zone(s), systems(s) and or plant(s) to which the feature(s) apply.

- Absorptance < 0.40
- Exterior Surface Emmissivity Different from DOE2.1E defaults.
- Any User-Defined Materials, Layers, Constructions, Assemblies
- Window-wall-ratio > 0.40
- Skylight-roof-ratio > 0.05
- Solar Heat Gain Coefficient (vertical or horizontal) < 0.40
- Fenestration ~~U-value~~U-factor (vertical or horizontal) < 0.50
- Use of "Industrial/Commercial Work - Precision" occupancy
- Process Fan Power
- Process Loads
- Tailored lighting input
- Lighting control credits
- Electric Resistance Heating or Reheating
- Hydronic (water source heat pumps)
- Economizer installed on equipment below 75,000 Btuh and 2500 cfm
- Variable speed drive fans
- Other high efficiency fan drive motors
- Verified sealed ducts in ceiling/roof spaces
- Any optional capabilities used

One consequence of **partial compliance** is that fewer forms are required and fewer forms will be printed. The forms, the total number of pages, and the runcode and initiation time printed on each of the forms must be consistent with the fewer number of pages allowed for partial compliance.

The PERF-1 form must also provide information on the service water heating system, including the system type, the efficiency of the water heating system or its components, pipe insulation specifications, and the fuel source used for service hot water.

When partial compliance is used or an addition is modeled with an existing building and its existing building components, these components must be flagged on the exceptional conditions checklist on the PERF-1 forms and the relevant EXISTING forms must be produced.

[SAMPLE COMPLIANCE FORMS ARE SHOWN IN APPENDIX E.]

2.7.2 Supporting Compliance Forms

The second type of standard reports that must be produced by all ACMs are the Supporting Compliance Forms including the ENV-2, LTG-2, MECH-2, MECH-3 and MECH-4 forms. Examples of versions of these forms are in Appendix E.

The ACM may also have algorithms or subroutines for prescriptive compliance and generate prescriptive compliance forms ENV-3, LTG-3, and LTG-4 automatically. If so, the pages of these forms must be tabulated and counted along with the performance forms for total page counts and verification on the PERF-1 form. If these forms are not used for a given performance compliance run, the ACM must not be able to print the forms with that performance compliance run. If they are utilized for a particular performance compliance run, the ACM must print them with the appropriate runtime and runcodes and correlate them with information on the PERF-1 form.

[SAMPLE COMPLIANCE FORMS ARE SHOWN IN APPENDIX E.]

CHAPTER 3. Reference Method and Optional Modeling Capabilities for Alternative Calculation Methods (ACMs)

Candidate ACMs may have more capabilities than the minimum required. These *optional capabilities* can be approved for use with the ACM for compliance purposes. Optional capabilities are those capabilities of an ACM that are not required as a Required Capability and for which there may or may not be specific capability tests in Chapter 5. Applicants wishing to receive approval of their ACM must meet all of the documentation requirements of the capabilities proposed and be prepared to defend the technical accuracy of any optional modeling capabilities during the ACM approval process.

The Commission does not require a program to have these capabilities, accept inputs for optional capabilities (except for *optional compliance capabilities*), or use these procedures in order to become certified. However, an ACM may offer optional capabilities to the user provided the specific capabilities have been certified by the Commission or the ACM meets all special conditions, conforms to all required calculational procedures, and passes certified tests for optional capabilities previously approved by the Commission for another ACM. The special conditions may include the capability to accept special input and produce special output for the optional capability. The Commission must review separate test results and specifically approve the ACM for these additional optional capabilities. The assumptions for the optional capabilities must be included in the vendor's submittal for optional capabilities as described in Sections 3.3 through 3.6. **For the purpose of compliance the use of any optional capability is considered an exceptional condition requiring special additional documentation to verify the distinctive features in the drawings and specifications related to the optional capability and to verify the particular inputs that are used to characterize the optional capability.**

An ACM's optional or additional capabilities must have specific tests, specific input and specific output requirements and these all must be approved by the Commission in writing. **Optional capabilities and any non-required ACM inputs that modify ACM results in such a way that can result in the ACM failing to meet the approval criteria for any test in Chapter 5 are specifically prohibited unless their use has been approved by the Commission as an optional capability. This is especially true for inputs and capabilities that cannot be modeled using the reference computer program.** This does not mean that ACMs may not differ in their inputs. For example, one ACM may accept wall heat capacity as an input, while another may use volume, density, and specific heat of the component wall materials to calculate the heat capacity, while another still may assume a heat capacity as a function of wall type. But no ACM may have an input for mass of phase change material in the wall and material phase change temperature without specific prior written approval of that capability and its associated inputs, outputs, and internal defaults and restrictions.

If any optional capability is modeled, the option must be specified on the appropriate compliance form automatically generated by the ACM. Additionally, ANY optional capability used in compliance must be listed on the Performance Summary form, PERF-1, page 2, as an exceptional condition which requires additional special documentation.

The ACM approval application (see Appendix A) must list and describe (or reference the description in the ACM User's Manual) all optional capabilities which are certified for compliance.

3.1 Compliance - Optional Capabilities

The following optional compliance capabilities may be allowed by nonresidential ACMs. Optional compliance capabilities include partial compliance and compliance for additions and alterations. There are specific output requirements for these options which are described in this Section and Section 2.7--Required Standard Reports.

3.1.1 Additions & Alterations

If the ACM is approved for the optional capabilities of alterations or automated calculation of Addition plus Existing Building, the **ACM must produce approved additional forms for existing building components and systems in accordance with the procedures described in Section 2.7 - Required Standard Reports.**

The Addition plus Existing Building calculation may also be performed by performing two separate runs. The first run is used to determine the budget for the existing building prior to the addition or alterations and the budget for a standard building similar to the existing building. These budgets are taken from the output for the proposed and standard building energy consumption using either the diagnostic output (if the existing building does not comply) or information from the PERF-1. The addition is modeled separately in the second run to determine the target budget for the addition space from the budget for the standard building for the addition. The budgets for these spaces are combined to determine a target budget for the combination of the two spaces. Budgets given in energy use per square foot per year are area weighted while budgets given in energy use per year for the total area can be added together.

The altered existing building plus the addition can then be modeled and the proposed building budget from that run must be less than the combined budget for the spaces above to get compliance.

When the addition is modeled separately and the existing HVAC system is to be expanded to serve both existing and new spaces, the HVAC system for the addition shall be modeled as a separate HVAC system of the same type as the existing HVAC system with similar efficiency characteristics (EER, COP, FPI, etc.)

3.1.2 Alteration or Addition Plus Altered Existing

ACMs that allow automated analysis of alterations of an existing building or an addition in conjunction with an existing building with alterations must perform compliance analysis of additions and alterations according to Section 149 of the Standards. This procedure also requires special and specific input and reporting procedures that complement the reporting requirements for a new building alone.

ACMs may use a two pass compliance procedure for an Addition plus Existing Building analysis similar to that used for the residential standards and described in the Residential ACM Approval Manual. See Section 3.1--Optional Compliance Capabilities--for more information on this technique. This technique requires the modeling of two different proposed designs with the ACM: (1) existing building and (2) the altered existing building combined with the proposed addition.

3.1.3 Output Reports

There are special output requirements for existing building components and characteristics that are passed directly to the standard design and compared against themselves in the custom budget process. In general, these must be reported on separate forms and in a distinctly different typestyle from new or altered building components and characteristics in output reports. To accommodate all printers this is done by using lowercase and UPPERCASE output to differentiate these inputs. See Section 2.7--Required Standard Reports--for more details.
To accommodate the optional capabilities of partial compliance and modeling additions with the existing building and alterations and deter circumvention of the standards, **all ACMs MUST report all new or altered**

user-entered building components and descriptive information completely in UPPERCASE TYPE. ACMs with the capabilities for partial compliance, modeling additions with the existing building or modeling alterations in an existing building **MUST report all information on existing, previously-approved building components that are not altered in lowercase type.** This is to insure that the local enforcement agency can readily determine the use of existing building components that do not have to meet the requirements of the building energy efficiency standards and distinguish these modeled components from those that are new or have been altered.

3.1.3.1 Graphical Output

Description: ACMs may include the ability to produce graphical output to facilitate the plan checking process. As part of the output documentation, ACMs may graphically show building's orientation, floors, walls, roofs, windows, skylights, thermal zones, and building cavities such as courtyards and atria. ACMs may either:

1. Draw isometrics showing all four sides of the building with adequate detail to visually verify the building's exterior features and interior cavities, or

2. Draw two-dimensional drawings showing side views of the building with adequate detail to visually verify the building's exterior features.

The graphical output shall:

a) Show the building orientation,

b) Show the envelope features such as exterior walls, exterior floors, roofs, exterior windows and skylights, and etc., including their size by showing their dimensions and location,

c) Show each footprint indicating the boundaries and dimensions of the footprint and the boundaries of occupancy and system areas associated with each footprint including occupancy types and system types, and boundaries and dimensions for building's interior cavities.

d) Show the boundaries of the building's thermal zones.

e) Show the overall ~~U-value~~U-factors of the opaque surfaces as well as the glazing on the drawing or in a tabulated form with reference to the drawing.

3.2 Overview of the Modeling Process

The modeling rules in the optional modeling approach are organized to facilitate the ACM software development and building modeling. The steps for modeling a building are as follows:

1. The user shall define construction types and layers of the proposed building envelope assemblies. The ACM shall model the proposed assemblies according to user inputs.

2. The ACM shall build the reference design envelope assemblies using the same construction types, materials and heat capacities as the proposed assemblies The ACM shall exclude any exterior and

interior insulation but, instead, shall adjust the cavity insulation R-value to meet the overall ~~U-value~~U-factor requirements for the assembly type and the climate zone.

3. The user shall define the building's footprint(s). A footprint is the plan view of a floor or a group of floors. A footprint includes building's interior cavities such as courtyards and atria. A building has one or more footprints. Each floor may have its own footprint or several floors of a building may have the same footprint. Floors have the same footprint if:

    a) They have identical plan views, i.e., having the same shape and area after including all building's interior cavities,

    b) They have identical floor to ceiling distances, and

    c) They have identical window patterns.

    This will reduce the amount of user inputs for modeling the envelope features of high-rise buildings which may only have a few different footprints. For each footprint, the user shall model the envelope features of the lowest floor having that footprint and the ACM shall duplicate these features for all floors of the high-rise building having that footprint.

    A footprint is surrounded by exterior walls separating the conditioned spaces from the ambient air and by demising walls separating the conditioned space from enclosed unconditioned spaces. By definition, indirectly conditioned spaces are considered conditioned spaces and are included in the footprint area. Footprints are modeled using the coordinates of their vertices relative to the building's reference point.

4. For every footprint, the user shall model exterior walls using the assemblies modeled in paragraph (1) above. The ACM shall model demising walls as *adiabatic* surfaces. ACMs may use an equivalent method to DOE-2's "FLOOR-MULTIPLIER" to model floors of the building which have the same footprint. Users must not model interior walls separating conditioned spaces within a building. ACMs shall account for the thermal capacity of interior walls according to the rules which will be described later in this manual. Exterior and demising walls are modeled using the coordinates of their vertices relative to the building's reference point.

5. The user shall describe all interior cavities--atria and courtyards--by specifying the coordinates of their vertices relative to the building's reference point for each and every footprint or floor where the cavity's plan view changes. Atria are considered as conditioned spaces but courtyards are considered as outside (ambient air). If an atrium is indirectly conditioned, it shall be modeled as part of adjacent spaces according to the rules which will be described later in this manual.

7. The user shall describe the occupancy areas by specifying the coordinates of the occupancy area's vertices relative to the building's reference point. An occupancy area is the space used by an occupancy type selected from Table 2-1.

8. The user shall describe building's system areas by specifying the coordinates of the area's vertices relative to the building's reference point. A system area is the space served by an HVAC system. For each HVAC system serving the building, the user must input the area that the system serves.

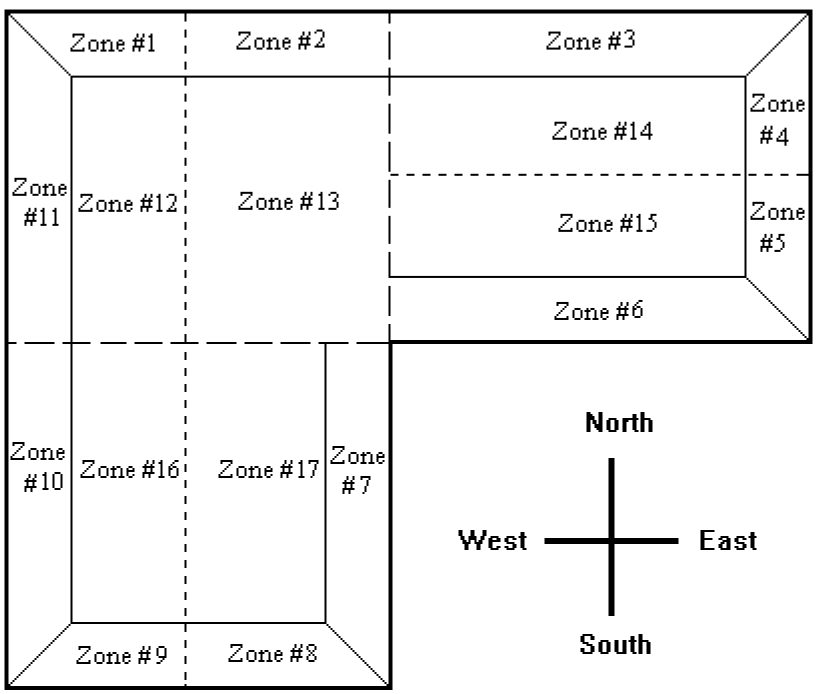
    1. The ACM shall automatically create thermal zones in accordance with the building geometry, occupancy areas, system areas and space types (interior or exterior) using the rules described in this manual. Each exterior space facing a different orientation or is within 45 degrees of that orientation is modeled as a separate exterior zone. All interior zones within a system area having the same occupancy type are combined. If a space has several occupancy types and is served by several HVAC systems, each combination of occupancy type, system type, space type (interior or

exterior), and whether the exterior zone is next to a North facing wall, East facing wall, South facing wall, and West facing wall is modeled as a separate thermal zone.

Thermal zones less than 300 ft^2 are combined with adjacent zones within the same HVAC system. Exterior zones next to courtyards must not be combined with other exterior zones even if they face the same orientation.

ACMs shall model the interface between thermal zones as air walls. ACMs shall model interior floors as input by the user, but must not allow modeling any interior walls. Walls separating conditioned spaces from indirectly conditioned spaces are considered interior walls. The heat capacity effect of interior walls and furniture shall be approximated by the program according to rules described in Section 2.2.2.13. The following example will illustrate zoning of a building with three occupancy types and six HVAC systems:

Example: Heavy lines show the building's footprint. Short dashed lines are boundaries separating system areas, long dashed lines are boundaries separating occupancy areas (from Table 2-1), and light solid lines show the thermal zone boundaries, which must be created by ACMs according to the rules described in Section 3.5.1.2.



3.3 Building Shell - Optional Capabilities

ACMs may use the following optional modeling approach for modeling the building shell. Unless otherwise specified in this section, ACMs shall determine the standard design according to the requirements of Section 2.2, Required Modeling Capabilities for the Building Shell.

All ACMs must receive inputs for each different opaque surface (wall, roof/ceiling, or floor) that separates conditioned from unconditioned space or the ground, including each demising wall (which consequently includes each party wall.) These inputs include construction framing type, orientation and tilt, location and area for each exterior surface. An ACM must also allow the user to enter inputs to determine heat transfer and heat capacity characteristics of exterior opaque surfaces for the proposed design. The heat capacity of standard design exterior surface is identical to the heat capacity of the proposed design exterior surface. Based on this heat capacity, the standards specify a required ~~U-value~~U-factor for the exterior surface that is used as the heat transfer characteristic for the standard design exterior surface.

For all exterior surfaces/assemblies it is assumed that the ~~U-value~~U-factors listed in the building standards include an exterior air film R-value of 0.17 h-ft^2-^{o}F/Btu, which the reference method strips off and replaces with a simulated outside air film resistance. Azimuthal orientation and tilts of surfaces must be entered to the nearest degree.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being “All”. An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as “All”.

All ACMs must separately report information about demising walls, fenestration in demising walls, exterior walls, and fenestration in exterior walls. Demising walls and demising wall fenestration separate conditioned and enclosed unconditioned spaces. Party walls are always considered to be demising walls when they separate spaces controlled or occupied by different tenants. For the purpose of compliance, the adjacent enclosed spaces not controlled by the tenant of the given space or by a single manager of the building are unconditioned. This assumption means that party walls are treated as demising walls and adjacent tenant spaces are modeled as enclosed unconditioned spaces. To avoid modeling adjacent spaces that are not part of the permit, for purposes of standards compliance, an ACM must assume that the demising wall is adiabatic and no heat transfer occurs through it.

3.3.1 Building Footprint

3.3.1.1 Footprint Identifiers

Description: A unique alphanumeric identifier for each footprint of the building. A footprint is the plan view of a floor which includes both directly and indirectly conditioned spaces and building cavities such as atria and courtyards but excludes unconditioned spaces.

Atria are considered conditioned spaces. If no HVAC system is specified for an atrium, ACMs shall assume that it is indirectly conditioned. Courtyards are considered as outside with ambient air. Walls, floors, and ceilings separating conditioned spaces from courtyards are considered exterior walls, floors, and roofs.

A footprint is surrounded by exterior walls separating conditioned spaces from the ambient air and by demising walls separating conditioned spaces from enclosed unconditioned spaces.

Floors of a building with identical plan view (having the same shape and area including building’s interior cavities), floor to ceiling height, and window patterns have the same footprint.

3.3.1.2 Floor Identifiers

Description: A unique alphanumeric identifier for each floor or a group of floors of the building having the same footprint identifier.

3.3.1.3 Number of Floors with the Same Footprint

Description: The number of floors having the same footprint.

DOE Keyword: FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must accept input for the number of floors that have the same footprint identifier according to the construction documents of the building.

Modeling Rules for Reference Design (All): The reference design shall use the same number of floors as the proposed design.

3.3.1.4 Footprint Area

Description: The total area of each footprint including directly and indirectly conditioned spaces and the building's interior cavities such as courtyards and atria.

A footprint is surrounded by exterior and demising walls with the exception of those separating the space from courtyards.

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: **For each footprint** of the proposed design, ACMs shall accept input for the area according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same footprint area as the proposed design.

3.3.1.5 Footprint Geometry

Description: Footprint geometry is described by the coordinates of its vertices defining the exterior perimeter of the footprint. The User must define the footprint geometry of the floor or the lowest floor of a group of floors having that footprint relative to the building's fixed reference point.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: **For each footprint** of the proposed design, ACMs shall accept input for the footprint vertices of the floor or the lowest floor of the building having that footprint according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same footprint vertices as the proposed design.

3.3.1.6 Geometry of Building's Interior Cavities

Description: The geometry of a building's interior cavities are described by the coordinates of the cavity vertices relative to the building's fixed reference point. Building's interior cavities include courtyards and atria.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The user shall describe all interior cavities--atria and courtyards--by specifying the coordinates of their vertices for each floor that the cavity's plan view changes even if those floors have the same footprints. ACMs shall accept input for the vertices according to the construction documents.

Modeling Rules for Reference Design (All): The reference design shall use the same cavity vertices as the proposed design.

3.3.2 Above-Grade Envelope

3.3.2.1 Footprint Identifiers

Description: Footprint Identifier as described above.

3.3.2.2 Exterior Partitions

Description: Above-grade exterior partitions surrounding each footprint that separate a conditioned space from the ambient air, attic space, crawl space, courtyard, or unconditioned spaces that are not enclosed. Exterior walls, raised floors, roofs, and ceilings are exterior partitions.

Return air plenums are considered conditioned spaces and must be modeled as part of the adjacent conditioned space.

3.3.2.3 Rectangular Exterior Partitions

Description: The area of rectangular exterior partitions for a footprint are defined by specifying the width of the partition and a height equal to the total height of the floor.

DOE Keyword: EXTERIOR-WALL
WIDTH
HEIGHT
FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each exterior partition of each floor, ACMs shall receive inputs for the height and width as they occur in the construction documents. The reference program shall use the DOE-2 Keyword "FLOOR-MULTIPLIER" to model identical floors belonging to the same footprint.

Modeling Rules for Reference Design (All): The standard design shall model each exterior partition with the same height and width as the proposed design.

3.3.2.4 Non-Rectangular Exterior Partitions

Description: The area of non-rectangular exterior partitions are defined by specifying the coordinates of the partition's vertices relative to a fixed reference point on the plane of the partition. The partitions height is equal to the total height of the floor.

DOE Keyword: EXTERIOR-WALL
X, Y
FLOOR-MULTIPLIER

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each exterior partition of each floor, ACMs shall receive inputs for the coordinates of its vertices as they occur in the construction documents. The reference program shall use the DOE-2 Keyword "FLOOR-MULTIPLIER" to model identical floors belonging to the same footprint.

Modeling Rules for Reference Design (All): The standard design shall model each exterior partition with the same coordinates for the vertices as the proposed design.

3.3.2.5 Positions of Exterior Partitions

Description: The coordinates describing positions of exterior partitions surrounding each footprint relative to the building's fixed reference point.

DOE Keyword: X, Y, Z

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall receive inputs for coordinates describing positions of the exterior partitions of the proposed building as they occur in the construction documents. ACMs shall also verify the connectivity of the building's exterior envelope including demising partitions (see Section 2.2.2.5). If this check fails, the ACM shall abort the compliance run and issue a message indicating which exterior partitions and/or demising partitions are not connected.

Modeling Rules for Reference Design (All): The reference design shall position the exterior partitions in the same manner as they occur and are modeled in the proposed design.

Note: ACMs shall not include in the model removed exterior and demising partitions as part of an alteration.

3.3.2.6 Positions of Fenestration Products

Description: The coordinates describing positions of the fenestration products in exterior partitions relative to a fixed reference point on the partition.

DOE Keyword: X , Y, SETBACK

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall accept position coordinates of fenestration products in exterior partitions as shown in the construction documents. ACMs shall also verify that the fenestration product is within the specified partition. If the verification fails, ACMs shall abort the compliance run and issue a message to the user that the verification has failed.

Modeling Rules for Reference Design (All): Positions of fenestration products in exterior partitions shall be modeled in the same manner as they occur and are modeled in the proposed design.

Note: ACMs shall not include in the model any removed fenestration as part of an alteration.

3.3.2.7 Self Shading

Description: ACMs may model shading of building surfaces by other portions of the building, such as one wing of a building shading another wing from direct sunlight.

DOE Keyword: SHADING-SURFACE
SHADING-DIVISIONS

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall model any *building self-shading* as input by the user, according to the plans and specifications for the building.

Modeling Rules for Reference Design (All): The ACM must model *building self-shading* in the standard design exactly as the proposed design.

3.4 Building Occupancy - Optional Capabilities

The user of an ACM must select an occupancy type from certain allowed tables. ACMs that do not have separate selection lists for ventilation occupancy assumptions and all other occupancy assumptions must allow the user to select from the occupancies and sub-occupancies listed in Table 2-1 and Table 2-2 or to select from an officially approved alternative sub-occupancy list that maps into those occupancies. ACMs that have separate occupancy selection lists for ventilation assumptions and other assumptions must use the occupancy selections given in tables in the building energy efficiency standards or approved alternative lists of occupancies. The occupancies listed in Table 1-F in the standards must be used for ventilation occupancy selections and the occupancies listed in Table 1-N in the standards must be used for selecting the remaining occupancy assumptions. Alternatively specific occupancy selection lists approved by the Commission that map into Tables 1-F or 1-N may be used.

A building consists of one or more occupancy types. ACMs may not combine different occupancy types. Tables 2-1 and 2-2 describe all of the schedules and full load assumptions for occupants, lighting, infiltration, receptacle loads and ventilation. Full load assumptions are used for both the proposed design and the reference design compliance simulations.

3.4.1 Occupancy Assignment

3.4.1.1 Occupancy Area

Description: A building consists of an occupancy type or several occupancy types selected from Table 2-1. Each occupancy type occupies a user specified *occupancy area* of the building. ACMs must be able to model a minimum of fifteen (15) occupancy areas. Each occupancy area may include two or more *sub-occupancy areas* selected from Table 2-2.

The reference method will model all interior floors separating occupancy areas and will model air walls between occupancy areas within each floor.

DOE Keyword: X, Y, Z

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must require the user to input the area and coordinates for the vertices of each *occupancy area* relative to the building's reference point. Occupancy area vertices shall define the location of each occupancy type within the building.

The reference program shall model interior floors between *occupancy areas* as they occur in the construction documents. For each floor, the reference program shall model air walls between *occupancy areas.*

ACMs must require the user to input information for each interior floor including construction, orientation, tilt, position and dimensions as it occur in the construction documents.

ACMs must model air walls with zero (0) heat capacity and an overall ~~U-value~~U-factor of 1.0 Btu/h-ft^2-^{o}F.

Default: One occupancy type in the entire building.

Modeling Rules for Reference Design (All): The standard design shall use the same vertices and area for each *occupancy area* as the proposed design.

The reference design shall model the same interior floors and air walls as the proposed design with the same surface areas, locations, thermal properties and construction.

3.4.1.2 Occupancy Types

Description: A modeled building must have at least one defined occupancy type. A default occupancy of "unknown" may be used to fulfill this requirement. Alternative Calculation Methods (ACMs) must model the following *occupancy* types. Occupancies that are considered as subcategories of these occupancies are listed below each occupancy. These occupancy types are also listed in Table 2-1 of this manual:

- Commercial and Industrial Work
  including both general and precision work, barber and beauty shops, laundries, and dry cleaning
- Grocery Store
  including convenience stores
- Industrial and Commercial Storage
- Medical/Clinical
- Office
  including banks & financial institutions, courtrooms, accounting, art, design drafting and engineering spaces
- Other
  including corridors, restrooms, and support areas as well as ALL others not specifically mentioned herein for spaces without lighting plans
- Religious Worship, Auditorium, Convention Center
  including exhibit display areas and lobbies associated with religious worship spaces, auditoriums, and convention centers
- Restaurant
  including dining rooms, kitchens, hotel function areas, bars, cocktail lounges, casinos
- Retail and Wholesale Store
- School
  including classrooms, day care, kindergarten, primary and secondary schools, trade schools, training centers, colleges, universities, research areas, laboratories
- Theater
  including movie theaters, live stage performance theaters, malls, arcades, and atria
- Unknown

Again, ACMs with default occupancies must use the "unknown" occupancy category as a default.

Alternative Calculation Methods (ACMs) must also model the following *sub-occupancy* types. These *sub-occupancy* types are listed in Table 2-2 of this manual. (Note: Some additional sub-occupancies are listed as subcategories of the sub-occupancies listed in Table 2-2):

- Auditorium
- Auto Repair Workshop
- Bank/Financial Institution
  including Banks, Savings & Loans, Credit Unions, Mortgage and Title Insurance
- Bar, Cocktail Lounge and Casino including cabarets, night clubs, bingo parlors and other gaming rooms with smoking
- Beauty Shop
- Barber Shop
- Classroom
  including areas for instructional purposes
- Commercial/Industrial Storage
  including warehouses and storage and stock rooms
- Commercial/Industrial Work - General, High Bay
  including manufacturing areas
- Commercial/Industrial Work - General, Low Bay

including manufacturing areas

- Commercial/Industrial Work - Precision
  Note: the use of this category is an exceptional condition and must be documented on the exceptional conditions checklist.
- Convention, Conference and Meeting Center
- Corridor, Restroom and Support Area
  including all circulation spaces, elevators, escalators, stairways, and janitorial room
- Courtrooms
- Dining Area
  including cafeterias and ballrooms
- Dry Cleaning (Coin Operated)
- Dry Cleaning (Full Service Commercial)
- Electrical, Mechanical Rooms
- Exercising Rooms and Gymnasium
  including day care, health clubs, sports arena, exercise rooms, dojos, spas, pools, saunas, and massage rooms
- Exhibit Display Area and Museum
  including art galleries
- Grocery Sales Area
- High-Rise Residential
- Hotel Function Area
- Hotel/Motel Guest Room
- Kitchen and Food Preparation
- Laundry
- Library - Reading Area
- Library - Stacks
- Lobby - Hotel
- Lobby - Main Entry
  including depots, terminals, and stations
- Lobby - Office Reception/Waiting
- Locker/Dressing Room
- Lounge/Recreation
- Mall, Arcade and Atrium
- Medical and Clinical Care
  including dental care, optical care
- Mixed Occupancy
- Office
  including accounting, counseling, art, drafting, design, insurance, stock & bond brokers, filing areas, conference rooms, mail rooms, telecommunications, and computer areas
- Other
- Religious Worship
  including churches, synagogues, temples, tabernacles, mosques, basilicas, cathedrals, missions, chapels, meditation areas, altars, shrines, worship centers, funeral homes, and memorials
- Retail Sales, Wholesale Showroom
  including pharmacies, drug stores, floral shops, video tape rentals
- Smoking Lounge
- Theater (Motion Picture)
- Theater (Performance)
  including dance halls and discotheques

- Unknown

Please note that this list is comprehensive given the categories "other" and "unknown." *Occupancies* and *sub-occupancies* other than those listed herein cannot be approximated by another *occupancy* or *sub-occupancy* unless that substitution has been approved by the Executive Director of the Commission in writing.

The selection lists accommodate unknown or miscellaneous unlisted occupancies. Any known occupancy not reasonably similar (as determined by the local building official) to an occupancy specified on a Commission-approved list is considered "other." Occupancies unknown to the applicant must use the occupancy type "unknown."

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs must require users to specify the occupancy type(s) for the building being modeled. For each occupancy type, ACMs must require the user to identify if lighting plans are included or have already been submitted. ACMs shall determine the occupancy type as follows:

Lighting compliance not performed. The ACM must require the user to select the *occupancy* type(s) for the building from the occupancies reported in Table 2-1. **The ACM must use the occupancy assumptions of this Table for compliance simulations**.

Lighting compliance performed. The ACM must require the user to select the *occupancy* type(s) for the building from the occupancies reported in Table 2-1. The ACM must also require input for the **percentage** of the *occupancy area* that each *sub-occupancy* type from Table 2-2 occupies**. The areas of sub-occupancy types must not be modeled. The ACM must use the *sub-occupancy* assumptions from Table 2-2 for compliance simulations**.

Tailored lighting and tailored ventilation are permitted as exceptional condition modifications to these default assumptions, but must be reported on the PERF-1 as exceptional conditions and on other applicable compliance forms. The tailored lighting values cannot be traded off for other features. Refer to sections for *Tailored Lighting and Tailored Ventilation* for respective requirements for each of these adjustments.

ACMs must use the same default assumptions, listed in Tables 2-1 through 2-6 of this manual including schedules, occupant densities, outside air ventilation rates, lighting loads, receptacle loads and service water heating loads. ACMs may have a separate occupancy list for ventilation versus other assumptions subject to the constraint that occupancy schedule types cannot be mixed. Users must select occupancy of a given space based upon the proposed or anticipated occupancy not on the amount of lighting desired. ACM input must emphasize occupancy choices and similarities not lighting choices. ACMs may <u>not</u> report the occupancy default lighting watts per square foot on the screen when the user is selecting occupancies for a space. After the occupancies are selected by the user, the lighting determined from the user's occupancy selection may appear on a separate entry screen as a default entry in the lighting power input if the user has not already entered it.

Modeling Rules for Reference Design (All): ACMs must model the same *occupancy* type(s) and *sub-occupancy* type(s) as the proposed building. ACMs must use the same default assumptions found in Tables 2-1 through 2-6. Tailored lighting and tailored ventilation are permitted as a modification to these default assumptions but must be reported on the PERF-1 exceptional condition list. Refer to sections for *Tailored Lighting and Tailored Ventilation* for respective requirements for each of these adjustments.

3.4.2 Occupancy Lighting

3.4.2.1 Lighting Controls

Description: Lighting controls have specific lighting power adjustment factors as listed in Table 1-L of the standards and any ACM may use these lighting control credits (subject to the requirements and specifications in Section 119 of the standards) just as they would with prescriptive compliance, except for the performance approach, credit cannot be taken for lighting controls that are required by other provisions of the standards, especially Sections 119 and 131. The ACM Compliance Documentation must describe how to determine which controls can be used for credit subject to this restriction. ACMs may explicitly model any of the lighting controls listed in Table 1-L of the standards. The ACM must require the user to input: 1) the area occupancy to which lighting controls are being applied; and, 2) the lighting control strategy or strategies being used. ACMs allow input for lighting control only when an *area occupancy type* has been input for the zone. ACMs with this optional capability must automatically generate a LTG-3, Lighting Controls Credit Worksheet, as part of the compliance documentation.

DOE Keyword: LIGHTING-W/SQFT

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model lighting controls in the proposed design as input by the user according to plans and specifications for the building.

Modeling Rules for Reference Design (New & Altered Existing): The reference design shall model only the lighting controls that are required by other provisions of the standards

Modeling Rules for Reference Design (Existing Unchanged): The reference design shall model lighting controls that are installed in the existing building.

3.4.2.2 Light Heat to Zone

Description: The reference method assumes that 100% of the heat due to lighting goes to the zone where the lighting is located. An optional capability may vary the lighting heat to the zone from 70%-100% and, consequently, the lighting heat to the return air from 0% to 30%, as a function of the type of lighting fixtures used in the zone. In the absence of persuasive evidence to the contrary, direct user entry of the allocation of lighting heat to the zone and the return air is considered an enforcement problem and is considered grounds for disqualification of an ACM from the approval process.

DOE Keyword: LIGHT-TO-SPACE

Input Type: Required

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall model the lighting heat-to-space and lighting heat-to-return air bases on the type of lighting fixtures used in the space as shown in the construction documents.

Modeling Rules for Reference Design (New & Altered Existing): The reference design shall use the same lighting heat-to-space and lighting heat-to-return air as the proposed design.

Modeling Rules for Reference Design (Existing Unchanged): The reference design shall model lighting heat-to-space and lighting heat-to-return air based on the lighting fixtures installed in the existing building.

3.5 Building Systems & Plants - Optional Capabilities

This section describes the rules for proposed design assumptions of optional systems and plant capabilities. The ACM must use the performance curves in the DOE-2 Supplement (Version 2.1D). If the described optional capability is not a capability of the Commission's reference computer program, vendors must include the required performance data for that capability. The assumptions in this section may be different than the corresponding assumptions specified in the Required Systems and Plant Capabilities, in order to model optional capabilities accurately.

Standard design requirements are labeled as applicable to one of the following options:

- Existing Unchanged
- Altered Existing
- New
- All

with the default condition for these four specified conditions being “All”. An ACM without the optional capability of analyzing additions or alterations must classify and report all surfaces as “All”.

3.5.1 Thermal Zoning

3.5.1.1 System Areas

Description: A space or collection of spaces within a building served by an HVAC system. ACMs must be able to model a minimum of fifteen (15) *system areas*.

DOE Keyword: X, Y, Z

Input Type: Default

Tradeoffs: Neutral

Modeling Rules for Proposed Design: For each system serving the building, ACMs must require the user to describe the area being served by the system by inputting the area and coordinates for the vertices of the *system area* relative to building's fixed reference point.

The reference program shall model an air wall between two *system areas* unless an air wall has already been modeled at that location as a boundary for two occupancy areas.

ACMs must require the user to input information for each modeled air wall including orientation, tilt, position and dimensions as they occur in the construction documents.

ACMs must model air walls with zero (0) heat capacity and an overall ~~U-value~~U-factor of 1.0 Btu/h-ft^2-^{o}F.

Default: One system type in the entire building.

Modeling Rules for Reference Design (All): The standard design shall use the same system areas as the proposed design.

The standard design shall model each air wall with the same thermal properties, orientation and tilt, position, and dimensions as the proposed design.

3.5.1.2 Thermal Zones

Description: A space or collection of spaces within a building having sufficiently similar space-conditioning requirements that those conditions could be maintained with a single controlling device. ACMs shall be able to model a minimum of 50 thermal zones.

DOE Keyword: ZONE

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: ACMs shall not accept input from the user for modeling thermal zones. Instead, ACMs must divide **each floor** of the building into thermal zones according to the following procedure:

1. Determine the ratio (R) of the floor's total conditioned area to the gross exterior wall area associated with the conditioned space.

2. For each combination of occupancy type, system type, and exterior wall orientation create a perimeter zone. The floor area of each perimeter zone shall be the gross exterior wall area of the zone times R or 1.25, whichever is smaller.

3. ACMs shall model the exterior space adjacent to each wall orientation as a separate exterior zone. ACMs shall include spaces adjacent to walls which are within 45 degrees of each orientation in the zone belonging to that orientation.

4. For cases where R is greater than 1.25, ACMs shall create an interior zone for each combination of occupancy type and system type. The floor area of the interior zone shall be the total system area less the floor area of the perimeter zones created in paragraphs 2 and 3 above.

5. ACMs shall prorate the roof area and the floor area among the zones according to the floor area of each zone. ACMs shall prorate the roof and floor areas among the perimeter zones created in paragraphs 2 and 3 above according to the floor area of each exterior zone.

6. Skylights shall be assigned to interior zones. If the skylight area is larger than the roof area of the interior zone, then the skylight area in the interior zone shall be equal to the roof area in the interior zone and the ACM shall prorate the remaining skylight area among the perimeter zones based on the floor area.

7. For each modeled system area, if the area of the zone is less than 300 ft^2, ACMs shall combine it with its adjacent zone of the same type (interior or exterior) which is served by the same HVAC system.

8. Courtyards are considered outside or ambient air. Walls, floors, and roofs separating conditioned spaces from courtyards are exterior walls, floors, and roofs. ACMs shall create an exterior zone for each wall orientation separating the conditioned space from the courtyard. ACMs shall **not** combine these exterior zones with other exterior zones even if their exterior walls have the same orientation.

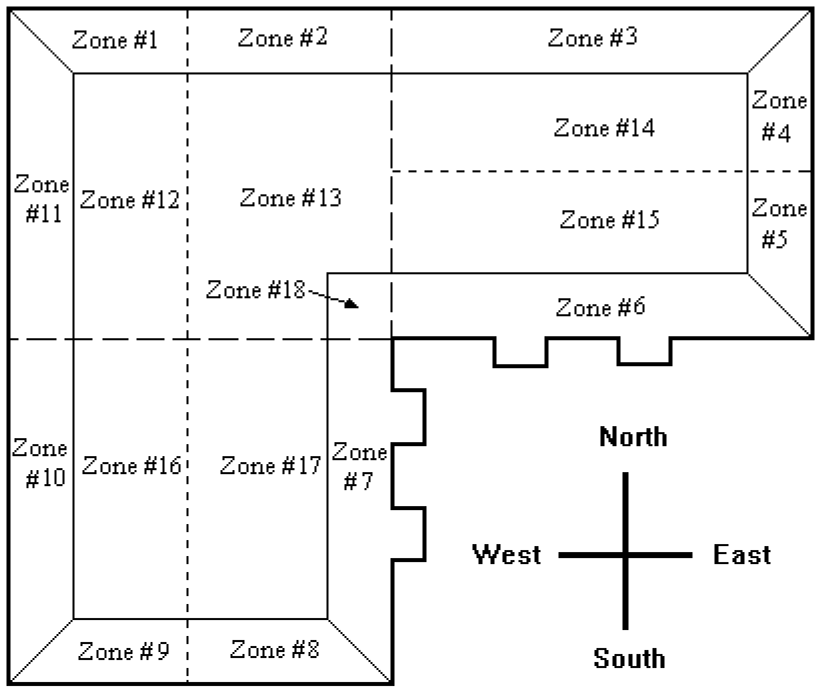
9. ACMs shall model spaces adjacent to demising walls as interior zones. ACMs shall combine these zones with other interior zones within the same occupancy area and system area.

10. ACMs shall include the exterior wall imperfections (exterior walls extending out for shading windows) in the exterior zone belonging to that exterior wall.

11. ACMs shall model air walls between thermal zones. ACMs must not allow the user to model any interior walls. Walls separating conditioned spaces from indirectly conditioned spaces are considered interior walls. The heat capacity effect of interior walls and furniture shall be approximated by

the program according to rules described in Section 2.2.2.13. ACMs shall model the actual interior floors between the thermal zones.

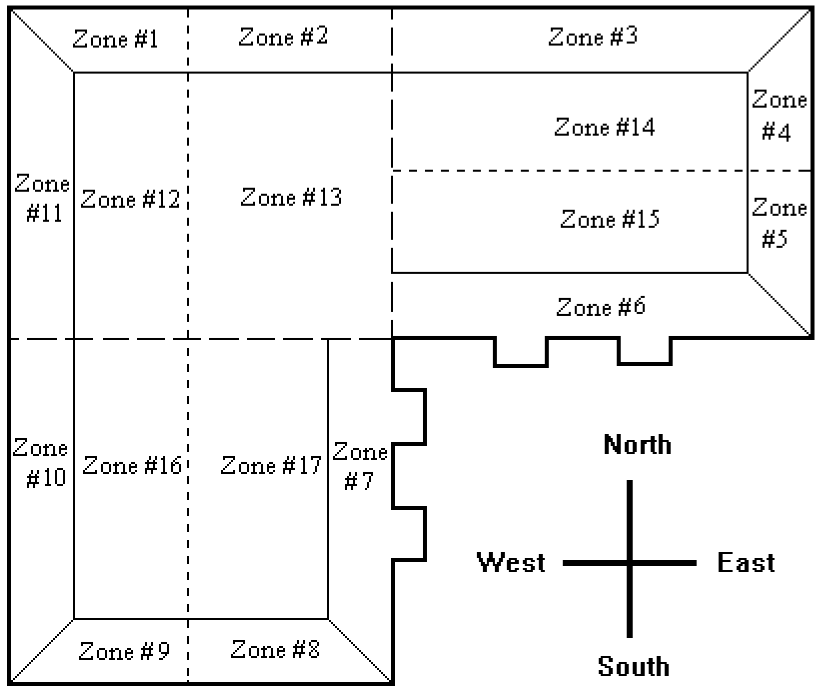
Example 1: Consider the following footprint. Using the above rules 1 through 6 the thermal zones will be as shown in the following drawing:



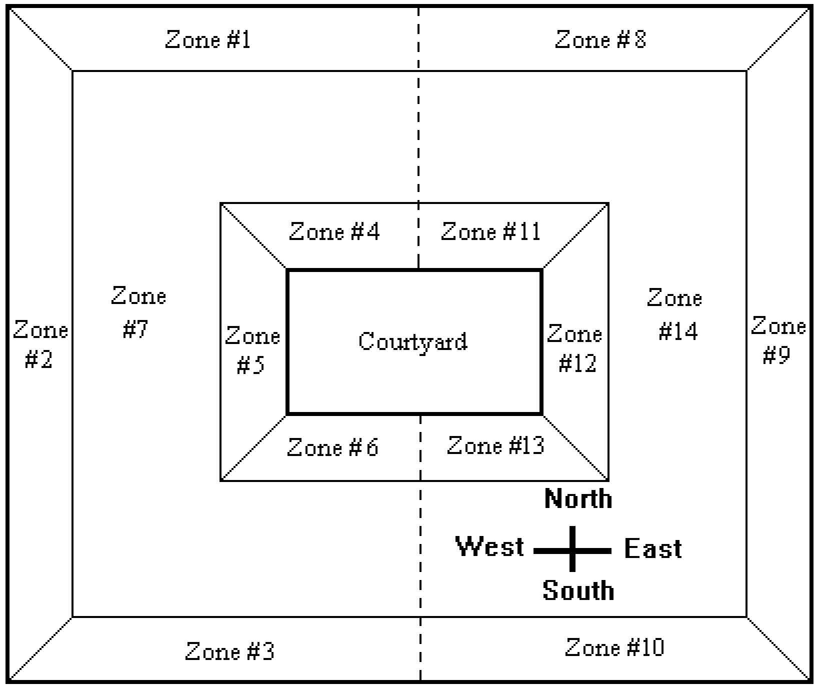
The zone areas are as follows:

Zone #1	500 ft^2	Exterior
Zone #2	750 ft^2	Exterior
Zone #3	1100 ft^2	Exterior
Zone #4	500 ft^2	Exterior
Zone #5	500 ft^2	Exterior
Zone #6	1300 ft^2	Exterior
Zone #7	1100 ft^2	Exterior
Zone #8	750 ft^2	Exterior
Zone #9	500 ft^2	Exterior
Zone #10	900 ft^2	Exterior
Zone #11	900 ft^2	Exterior
Zone #12	1300 ft^2	Interior
Zone #13	2200 ft^2	Interior
Zone #14	1400 ft^2	Interior
Zone #15	1400 ft^2	Interior
Zone #16	1300 ft^2	Interior
Zone #17	1500 ft^2	Interior
Zone #18	225 ft^2	Interior

Zone #18 is an interior zone whose area is less than 300 ft^2. Therefore, according to rule #7 above, zone #18 is absorbed by the adjacent interior zone within the same HVAC system.   The zoning will change as follows:



Example 2: Consider the following footprint. The heavy solid lines are the boundaries separating the conditioned space from the ambient air. The dashed line indicates separation between two different occupancy areas (from Table 2-1). Each occupancy area is served by a different HVAC system. The footprint includes a courtyard in the middle. The zoning will be as follows:

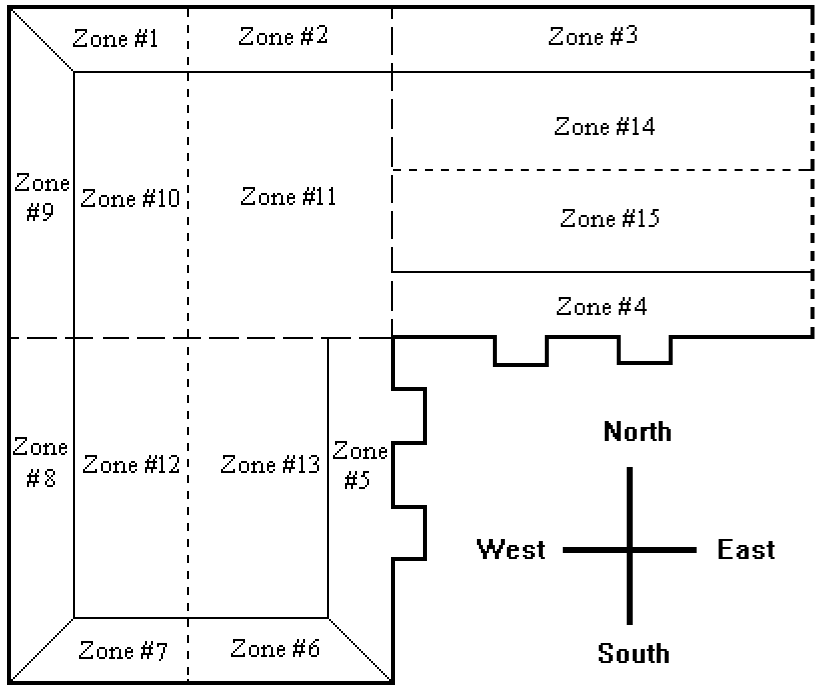


The zone areas are as follows:

Zone #1	1100 ft^2	Exterior
Zone #2	1800 ft^2	Exterior
Zone #3	1100 ft^2	Exterior
Zone #4	500 ft^2	Exterior
Zone #5	700 ft^2	Exterior
Zone #6	500 ft^2	Exterior
Zone #7	6900 ft^2	Interior
Zone #8	1100 ft^2	Exterior
Zone #9	1800 ft^2	Exterior
Zone #10	1100 ft^2	Exterior
Zone #11	500 ft^2	Exterior
Zone #12	700 ft^2	Exterior
Zone #13	500 ft^2	Exterior
Zone #14	6900 ft^2	Interior

All zones are larger than 300 ft^2, therefore, zones will not be combined.

Example 3: This building is the same as the building in example 1, except that the east facing wall is a demising wall.



Modeling Rules for Reference Design (All): ACMs shall model the thermal zones of the reference design in the same manner as they are modeled in the proposed design.

3.5.2 Heating & Cooling Equipment

3.5.2.1 Types of HVAC Systems and Central Plants

Description: ACMs may have the capability to model other types and variations of HVAC systems and central plants. These variations may incorporate alternative designs for:

- Single zone heating and cooling equipment
- Direct and indirect evaporative cooling equipment
- Multiple zone air distribution systems
- Fan volume control
- Water chilling
- Building waste energy recovery
- Building heat rejection
- Renewable energy sources
- Air and water economizer cycles

The Commission has approved a list of these optional capabilities for performance compliance. These capabilities are documented below, along with all required inputs and assumptions for both standard and proposed designs.

DOE Keyword: SYSTEM-TYPE
PLANT-EQUIPMENT
TYPE

INSTALLED-NUMBER

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model the systems and plants of the proposed design as input by the user according to the plans and specifications of the proposed building.

Modeling Rules for Reference Design (New): ACMs shall always determine the standard design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing systems and plants an they occur in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.2 Absorption Cooling Equipment

Description: ACMs may model heat operated (absorption) cooling equipment with the following features:

- *One-stage absorption*. Heat operated water chiller. With this option, the ACM must account for absorber and refrigerant pump energy and purge cycle.
- *Two-stage absorption.* Heat operated water chiller using two stage or double effect concentrator. With this option, the ACM must account for absorber and refrigerant pump energy and purge cycle.
- *Economizer.* For absorption chiller, absorber solution flow to the concentrator is modulated as a function of load.
- *Steam fired.* Absorption chiller uses steam as the heat source.
- *Hot water fired.* Absorption chiller uses hot water as the heat source.
- *Direct fired.* Absorption chiller uses fossil fuel as heat source.

DOE Keyword: PLANT-EQUIPMENT
ABSOR1-CHLR
ABSOR2-CHLR
ABSORG-CHLR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for The ACM shall model absorption equipment in the proposed design as input by

Proposed Design: the user according to the plans and specifications for the building. The ACM shall use performance relationships according to the DOE 2.1 default equipment curves.

Modeling Rules for Reference Design (New): ACMs shall determine the standard design according to the requirements of the Required Systems and Plant Capabilities and Figure 2-1.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.4 Heating Equipment Options

Description: ACMs may model double bundle condensers on cooling equipment for heat recovery.

DOE Keyword: N/A

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model heating equipment options in the proposed design as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.5 Exhaust Heat Recovery

Description: ACMs may model the following methods of heat recovery as input by the user.

- *Heat pipe.* Heat recovered from exhaust air is transferred to supply air via passive heat transfer coil (typically using refrigerant as the medium). No mechanical energy is required for heat recovery. With this option, the ACM must account for additional coil pressure drops.

- *Hydronic loop.* Heat recovered from exhaust air is transferred to supply air via hydronic system including coils in each air stream and water circulation system (run-around system). With this option, the ACM must account for circulating pump energy and accounts for additional coil pressure drops.

- *Heat wheel sensible.* Heat recovered from exhaust air is transferred to supply air via mechanically rotating heat wheel. The wheel may transfer sensible heat. With this option, the ACM must account for heat wheel motor energy and accounts for additional coil pressure drops.

DOE Keyword: RECOVERY-EFF
SUPPLY-1 thru SUPPLY-5
DEMAND-1 thru DEMAND-5

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model heat recovery options in the proposed design as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.6 Proposed System Types

Description: ACMs may model HVAC system types not included in the list of 5 minimum standard and proposed system types. Specifically, ACMs may model the following proposed system types:

- **System 6:** *Hydronic Heat Pump.* Zone cooling/heating capability may be provided by a zonal hydronic heat pump connected to a central water heat source/heat rejection loop, shared by other zonal hydronic heat pumps.

- **System 7:** *Single Fan/Dual Duct.* A single fan blows supply air through the heating and cooling coils and into the hot and cold supply ducts, with either a constant or variable volume fan. Zone terminal units mix hot and cold supply air streams to meet zone loads.

- **System 8:** *Dual Fan/Dual Duct.* Two separate central fan systems, one for heating and one for cooling, using either constant or variable fans, distribute air to the building. Zone terminal units mix hot and cold supply air streams to meet zone loads. **If this system is included, the ACM must also simulate heating supply air reset, described below.**

- **System 9:** *Direct and Indirect Evaporative Cooling*. Evaporative cooling may be modeled as the only cooling system or as a precooler for another cooling system. The systems may utilize direct evaporative cooling only; indirect evaporative cooling only; indirect/direct evaporative cooling; or evaporatively precooled condensers. Direct or indirect evaporative precooling of supply air may also be modeled but no tests or specifications are defined for these options. Users must be able to specify evaporative cooler fan capacity and brake horsepower (bhp), water pump capacity and brake horsepower (bhp), and whether or not the evaporative cooler can operates in conjunction with another cooling system. When evaporative cooling systems are modeled, default measures of direct and indirect (where applicable) cooling efficiencies must be supplied. Subject to Commission approval, the user may be allowed to override these defaults.

Perimeter Systems. Independent HVAC systems (typically heating only) which serve perimeter zones in addition to a primary system (typically cooling only). Perimeter systems differ from zone terminal systems in that they are independent: They do not connect to the primary system but supply heating/cooling through separate air outlets or heat transfer surfaces. There are two common types of perimeter systems.

- **System 10:** *Convective/radiant*. Zone perimeter system may be a convective or radiant system, such as baseboard or radiant ceiling panels.

- **System 11:** *Constant volume system*. Zone perimeter system provides heating/cooling by constant air volume supply to each zone served. System may or may not have outside air supply capability.

Perimeter systems may incorporate the following features **(NOTE that perimeter systems may be specified as serving the same zone(s) as any of Systems 1 through 9)**:

- *Master zone*. Used when the perimeter system heating/cooling supply is controlled to satisfy the thermostat of a given zone.

- *Multiple zones*. Used when the perimeter system serves more than one zone of the primary system. (This allows modeling of "fighting" between the primary and perimeter system.)

- *Electric*. Used when the perimeter system heating is electric resistance.

- *Hydronic*. Used when the perimeter system cooling/heating coil is served by a central hydronic system.

- *DX*. Used when the perimeter system cooling is provided by direct expansion refrigerant coils served by a heat pump or other compression system (see PLANT equipment.)

DOE Keyword: SYSTEM-TYPE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: Optional proposed systems shall be modeled as input by the user, according to the plans and specifications for the building, subject to all of the restrictions specified in the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (New): Standard system types and applicable system parameters are chosen according to Figure 2-1. The air flow and supply air temperature for the standard design will be optimally controlled in the reference method. All efficiency descriptors shall be determined according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using DOE-2 default performance curves. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.7 Combined Hydronic Systems for Nonresidential Buildings

Description: Combined hydronic water heating systems for nonresidential buildings may be modeled as an optional capability. Vendor-proposed prescribed assumptions for this method are crucial. All user-defined inputs must be enforceable. Variables which are difficult to plan and field verify should be incorporated as prescribed inputs. The residential water heating calculation methodology is a useful example for compliance-based combined hydronic heating system modeling.

3.5.2.8 Combined Hydronic Systems for High-Rise Residential Buildings

Description: Combined hydronic water heating systems evaluation for high-rise residential buildings should be evaluated in a manner consistent with the low-rise residential combined hydronic system methodology. A vendor-proposed optional capability should incorporate the majority of efficiency measures evaluated by the low-rise residential method and should be reasonably consistent with those procedures, especially near the transition between low-rise and high-rise buildings. Inputs and analysis of wood stoves and wood-fired boiler are not required (in fact discouraged) to be included as part of the optional capability.

3.5.2.9 Equipment Efficiency

Description: ACMs may model equipment according to factory supplied performance data. The following performance relationships may be modeled:

- *All Packaged Cooling Equipment*
  - Capacity as a function of entering wet-bulb and outside dry-bulb temperatures
  - Cooling electrical efficiency as a function of entering wet-bulb and outside dry-bulb temperatures
  - Cooling electrical efficiency as a function of part-load ratio
  - Sensible cooling capacity as a function of entering wet-bulb and outside dry-bulb temperatures

- *Packaged VAV Cooling Equipment Only*

* Capacity as a function of supply air quantity
* Cooling electrical efficiency as a function of supply air quantity
* Sensible cooling capacity as a function of supply air quantity

- *Water Chillers*
  * Capacity as a function of exiting chilled water and entering condenser water temperatures
  * Cooling electrical efficiency as a function of exiting chilled water and entering condenser temperatures

- *Furnaces*
  * Fossil fuel furnace efficiency

- *Heat Pumps*
  * Heating electrical efficiency as a function of outdoor dry-bulb and entering dry-bulb temperature

- *Boilers*
  * Fossil fuel boiler efficiency

DOE Keyword: COOLING-EIR
HEATING-HIR
FURNACE-HIR
HW-BOILER-HIR
BOILER-EIR
BOILER-HIR

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model performance of proposed systems and plant equipment, except for fans, using DOE-2 default performance curves for the equipment specified in the construction documents for the building.

Low Value: Minimum efficiency requirement

Modeling Rules for Reference Design (New): ACMs shall model performance of all systems and plant equipment, except for fans, according to requirements of the Required Systems and Plant Capabilities, and the default performance curves listed in the DOE 2.1E supplement.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using the system's actual efficiencies according to requirements of the Required Systems and Plant Capabilities and DOE-2 default performance curves. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.10 Cooling Towers

Description: ACMs may model several options for cooling tower operation which may be specified at the user's option. These options are described below:

- *Closed circuit.* Condenser water is cooled indirectly by a heat exchanger which is evaporatively cooled (fluid cooler). With this option, the ACM must account for spray pump energy. If the ACM has this capability, it must require the user to specify if the cooling tower uses an open or closed circuit.

- *Axial fan.* An axial fan provides ambient air flow across tower fill or closed tower heat exchanger.

- *Natural draft.* Ambient air flow across tower fill is natural draft (not mechanically driven) as defined by user input tower dimensional data and draft factor.

- *Discharge dampers.* Tower (condenser) capacity is controlled by modulating fan discharge dampers.

- *Bypass.* Tower leaving water temperature is controlled by bypassing tower return water around tower to the supply line, thereby cooling only a portion of the water flow.

- *Variable speed drive:* Tower (condenser) capacity is controlled by varying fan motor speed.

DOE Keyword: TWR-CAP-CTRL
TWR-MIN-FAN-SPEED
FLUID-BYPASS

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model all optional cooling tower features as input by the user according to the construction documents for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building using the system's actual efficiencies. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.11 Pump Controls

Description: ACMs may model several optional pump design, operation and control strategies which may be specified at the user's option. These options are described below:

- *Variable flow.* Used when the variable flow, constant temperature system flow rate varies as a function of load.

- *Riding curve*. Pump(s) ride characteristic performance curve as a function of head pressure. Head pressure will vary depending on the water demands of cooling and heating coils and the amount of water bypassing different zones.

- *Two speed/stages*. Used when the pumps are staged, or pump has two speed motor, to maintain pressure requirements. Pump(s) ride characteristic curve between stages.

DOE Keyword: TWR-PUMP-HEAD
TWR-IMPELLER-EFF
TWR-MOTOR-EFF
CIRC-IMPELLER-EFF
CIRC-MOTOR-EFF
CIRC-HEAD
CIRC-PUMP-TYPE
DHW-PUMP-ELE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall model optional features of proposed design pumping systems as input by the user according to plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.12 Fan Volume Control

Description: The ACM may model the following optional types of fan volume control, as input by the user. Default fan curves are given in terms of DOE-2 curve-fit instructions.

- *Air foil centrifugal fan with discharge dampers (ride fan curve).* Fan volume is controlled by a controllable damper mounted at the fan discharge, or the fan "rides" its characteristic fan curve against varying system pressure.

```
AF-FAN-W/DAMPERS = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.68
DATA =      (1.0,1.0)
            (0.9,0.95)
            (0.8,0.90)
            (0.7,0.86)
```

```
(0.6,0.79)
(0.5,0.71) ..
```

- *Vane-axial fan with variable pitched blades.* Fan volume is controlled by varying blade pitch.

```
VANE-AXIAL-FAN = CURVE-FIT
TYPE = QUADRATIC
OUTPUT-MIN = 0.15
DATA =     (1.0,1.0)
           (0.9,0.78)
           (0.8,0.60)
           (0.7,0.48)
           (0.6,0.36)
           (0.5,0.27)
           (0.4,0.20)
           (0.3,0.23)
           (0.2,0.22) ..
```

DOE Keyword: FAN-CONTROL

Input Type: Prescribed

Tradeoffs: Neutral

Modeling Rules for Proposed Design: The ACM shall model supply and return fans chosen by the user and as documented on the plans and specifications for the building for the proposed design fan system. The ACM shall use the performance data given in this manual.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.13 Multiple Fan Volume Controls

Description: ACMs may model different fan volume control strategies for supply, return and relief fans. If the ACM has this capability the user may specify a different strategy for each fan in the fan system.

DOE Keyword: FAN-CONTROL

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model fan volume controls for each proposed design fan as input by the user. If different fan volume controls are not input for supply, return and/or relief fans, the ACM shall assume all fan volume controls for the entire fan system to be the same as that specified for the supply fan.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.14 Air Economizers

Description: The ACM may model the following optional economizer control strategies when specified by the user:

- *Outside air enthalpy*. Economizer cooling is enabled as long as the outside air enthalpy is less than 29 Btu/lb.
- *Variable enthalpy*. Equivalent to the Honeywell W7400 or H205 humidity biased enthalpy control using set-curve A.
- *Differential dry-bulb*. Economizer cooling is enabled as long as the return air temperature is greater than the outside air temperature.
- *Differential enthalpy*. Economizer cooling is enabled as long as the return air enthalpy is greater than the outside air enthalpy.
- *Economizer High Limit*. When a differential controller is used, a high limit, above which the economizer cannot operate, may also be added. The high limit controller can either be a dry-bulb (set at 75 degrees), an enthalpy (set at 29 Btu/lb) or a variable enthalpy controller.
- *Non-integrated, two stage operation*. The economizer operates as the first stage of cooling until the cooling load cannot be met by the economizer. At this point, the economizer closes to the minimum position and mechanical cooling is used to meet the cooling load. If this strategy is selected, an outdoor high limit of 70 ODB or 28.5 Btu/lb shall be used.

DOE Keyword: OA-CONTROL
ECONO-LIMIT-T
ECONO-LOCKOUT
ENTHALPY-LIMIT
DRYBULB-LIMIT

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs shall limit proposed design optional economizer control strategies to those listed in this section, including set points.

Default: No economizer

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.15 Water Side Economizers

Description: ACMs may model the following water side economizers when specified by the user:

- *Strainer cycle*. Used when cooling tower water is diverted to the main cooling coil for "free cooling" when the cooling tower leaving water temperature is low enough to meet the total building load. This type of water side economizer can only be used in place of, and cannot be used to supplement, mechanical cooling.

- *Series coil*. A cooling coil, connected to the condenser water loop ahead of the condenser, is placed in the air handler upstream of the main cooling coil. This coil is used to supplement mechanical cooling, when the cooling benefit is greater than the added pumping energy needed to circulate cooling tower water through the cooling coil.

- *Evaporator precooling (heat exchanger)*. A heat exchanger is used to transfer heat from condenser water, prior to entering the condenser, and chilled water, prior to entering the evaporator, in order to precool the chilled water. If the difference between the return chilled water temperature and cooling tower leaving water temperature is large enough to provide a cooling benefit, the heat exchanger is used to supplement mechanical cooling.

- *Evaporator precooling (cooling tower)*. Chilled water is circulated through a closed loop in the cooling tower before entering the evaporator. If the difference between the chilled water return temperature and outside wet-bulb temperature is large enough to provide a cooling benefit, chilled water is circulated to the cooling tower to supplement mechanical cooling.

DOE Keyword: WS-ECONO
WS-ECONO-MIN-DT
WS-ECONO-XEFF
CONDENSER-TYPE
FLUID-VOLUME

COND-FLOW-TYPE
COND-WTR-FLOW

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model the proposed system water side economizer as input by the user, according to the plans and specifications for the building. If a strainer cycle is specified, change-over temperature from economizer to mechanical cooling must be set at 50 ^{o}F.

Default: No economizer

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.16 Zone Terminal Controls

Description: ACMs may model the following optional features for zone terminal controls, as input by the user:

- *Constant volume.* Zone receives a constant volume of air regardless of thermostat signal.
- *Mixing hot deck/cold deck.* Zone temperature is controlled by mixing hot and cold air.
- *Induction.* Supply air induces room or return plenum air into the supply air stream.
- *Fan powered induction.* Zonal fan supplies return or room air optionally mixed with system supply air (if any).
- *Series.* Fan powered induction system where zonal fan is in series with primary system supply air. Fan runs continuously when central system is on providing constant volume to space.
- *Parallel.* Fan powered induction system where zonal fan is in parallel with primary system supply air. Primary supply is usually VAV. Fan cycles on only when heating is required.
- *Series/Parallel.* Fan powered induction system where zonal fan is in parallel with primary system supply air. Primary supply is usually VAV. Fan cycles

on to maintain a minimum supply volume and when heating is required.

DOE Keyword: TERMINAL-TYPE

Input Type: Required

Tradeoffs: Yes

Modeling Rules for Proposed Design: The ACM shall model optional zone terminal control features as input by the user according to the plans and specifications for the building.

Modeling Rules for Reference Design (New): The ACM shall model the reference design according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.5.2.17 Renewables

Description: The depletable energy savings associated with solar collector systems must be analyzed according to certified methods such as f-Chart which have been approved by the Commission for use with the low-rise residential standards (see *Alternative Calculation Method (ACM) Approval Manual for the ~~1998~~2001 Energy Efficiency Standards for Residential Buildings*). A nonresidential ACM may be approved with the optional capabilities of built-in f-Chart and/or passive solar collector performance calculations.

Vendors who wish to have their nonresidential ACMs approved with either of these capabilities must meet the requirements described in the residential ACM manual.

DOE Keyword: N/A

Input Type: Default

Tradeoffs: Yes

Modeling Rules for Proposed Design: ACMs may model solar water heating as an energy source for service hot water heating only.

Default: No renewable energy is used.

Modeling Rules for Reference Design (New): ACMs shall not model renewable energy sources for any of the standard design energy use.

Modeling Rules for Reference Design (Existing Unchanged & Altered Existing): ACMs shall model the existing system as it occurs in the existing building. If the permit involves alterations, ACMs shall model the system before alterations.

3.6 Vendor Defined Optional Capabilities

Vendors may propose other optional capabilities not specifically described in this manual. In the proposal for vendor specified optional capabilities, the vendor shall include:

- Theoretical background and simulation algorithms
- Testing data and validation analysis for all specified capabilities
- Standard and proposed design assumptions
- Specific documentation requirements, addressing enforceability by building department personnel

The Commission, during the certification process, may require changes to the vendors' proposed methods in order to gain consistency with other vendors' proposing similar capabilities.

CHAPTER 4. Alternative Calculation Method (ACM) Compliance Documentation

Each ACM vendor is required to publish a compliance supplement to their normal program user's manual, or an independent user's manual in which relevant compliance information is easily located and clearly presented. The purpose of this required document is to facilitate compliance with the Standards and the use of the ACM for compliance purposes. This document must deal with compliance procedures and user inputs to the ACM rather than the internal workings and assumptions of the ACM that the ACM uses to determine budgets or compliance. Both the ACM and its compliance documentation must positively contribute to the user's ability and desire to comply with the Standards and to the enforcement agency's ease of verifying compliance. The ACM Compliance Documentation should minimize or reduce confusion and clarify compliance applications. The Commission may reject an ACM whose ACM Compliance Documentation does not serve to meet these objectives. All further references in this chapter to the "ACM Compliance Documentation" refer to the ACM Compliance Supplement or the ACM Compliance User's Manual.

4.1 Overview

The ACM Compliance Documentation must describe the specific procedures for using the ACM for compliance with the Energy Efficiency Standards for Nonresidential Buildings. The ACM Compliance Documentation must provide instructions for preparing the building input, using the correct inputs and using each of the optional capabilities (or exceptional methods) for which the ACM is approved. Also included are procedures for generating the standard reports and related documentation. A sample of a properly documented building analysis must be included.

The ACM Compliance Documentation serves two major purposes:

- It helps building permit applicants and others use the ACM correctly, and guides them in preparing complete documentation for compliance submittals.

- It helps building department staff plan check permit applications for compliance with the nonresidential standards.

The ACM Compliance Documentation serves as a crucial performance method reference in resolving questions concerning specific ACM program attributes, approved modeling capabilities and procedures in the context of both compliance and enforcement.

The Commission actively discourages vendors and applicants from describing the internal algorithms and assumptions and giving information that is not essential to the user to comply with the standards or to resolve compliance-related issues regarding ACM inputs. Once an ACM has been approved, users may not modify or manipulate many aspects that the ACM's calculational engine normally allows users to modify.

ACM users or vendors may disagree with the restrictions, assumptions, and limitations required for an ACM to be approved. However, the proper forum for debate regarding custom budget procedures and the details of the reference method is Commission workshops and hearings on the ACM Approval process and future revisions to this manual, not the front desk of the local enforcement agency or the pages of the ACM Compliance Documentation. For example, the schedules used by the ACM may not be altered by the user and the schedules should not be described in the ACM compliance document. In a similar manner, the ACM Compliance Documentation should not report or describe information that is not directly related to ACM user inputs and required outputs needed for compliance or information needed to clarify questions about ACM user inputs for compliance-related issues.

4.2 Modeling Guidelines and Input References

The ACM Compliance Documentation must contain a chapter or section on how to model buildings for compliance and how to prepare a building input file for a compliance run. Topics shall include:

- What surfaces to model (exterior, interior floors, etc.);
- How to enter data about these surfaces;
- How to model exterior shading (fins, overhangs, etc.);
- Appropriate zoning for compliance modeling;
- Selection of correct occupancy types;
- How to model like systems;
- How to model buildings or portions of a building with no heating or cooling;
- Requirements for written justification and additional documentation on the plans and in the specifications for items on the PERF-1 Exceptional Conditions Checklist;
- Correct use of the standard design modifiers including tailored lighting allotment, and display perimeter if the ACM results are modified by these user inputs;
- Program modeling limitations; and
- The *Nonresidential Manual* as required reading.

All program capabilities should be described in sufficient detail to eliminate possible confusion as to their appropriate use. While references to the ACM's regular users manual are acceptable, a complete listing of all inputs and/or commands necessary for compliance should be included in the ACM Compliance Documentation. The following compliance issues should be explained in the ACM Compliance Documentation or user's manual of each ACM.

4.3 Required Modeling Capabilities

4.3.1 Required Compliance Capabilities

4.3.1.1 Format

Description: The ACM Compliance Documentation must be written in a clear and concise manner. The suggested format is:

- An introduction or overview explaining the use of the ACM for compliance with the Energy Efficiency Standards for Nonresidential Buildings.
- A chapter or section which covers every input that can be used for compliance analysis.

- A chapter or section which covers each standard form or relevant report.
- Appendices, as needed, to provide any additional background information, or additional examples of compliance submittals.

Although the organizational format is not fixed, all information contained in the ACM Compliance Documentation must be easy to find through use of a detailed Table of Contents and/or an Index.

4.3.1.2 Modeling Guidelines

Description: The ACM Compliance Documentation must contain clear and detailed information on how to use the ACM to model buildings for compliance with the Standards. At a minimum, the ACM Compliance Documentation must provide explanations and instructions outlined in Section 3.2.

Each ACM Compliance Documentation or User's Manual must include a general listing of the following:

1. Description of the value or values associated with each of input.
2. Restrictions on each variable.
3. Listing of the range beyond which inputs are unreasonable for any variable.
4. Description of options for any user-defined variable.

4.3.1.3 Statement

Description: The following statement must appear, in a box, within the first several pages of the ACM Compliance Documentation:

[ACM Name] may be used to show compliance with California's Energy Efficiency Standards for Nonresidential Buildings only when the following reference documents are readily available to the program user:

1. ***~~1998~~ 2001 Building Energy Efficiency Standards (P400-~~98~~00-031~~01~~)***
2. ***Nonresidential Manual (P400-98-005) and its 2001 Supplement***

Both publications are available from:

California Energy Commission
Publications Office
1516 Ninth Street, MS-13
P.O. Box 944295
Sacramento, CA 94244-2950
(916) 654-5200

4.3.1.4 Copies of ACM Compliance Documentation

Description: ACM vendors are required to make a copy of the ACM Compliance Documentation available to any California building department that requests it.

4.3.1.5 Commission Approval

Description: A section of the ACM Compliance Documentation must include a copy of the official Commission notice of the approval of the ACM. The notice may include restrictions or limitations on the use of the ACM. It will also include the date of approval, and may include an expiration date for approval as well. The notice will indicate optional capabilities for which the ACM is approved and other restrictions on its use for compliance. The Commission will provide this notice upon completion of evaluation of the ACM application.

4.3.2 Required Loads Capabilities

4.3.2.1 Conditioned Floor Areas

Description: The ACM Compliance Documentation must describe how the user determines and enters the conditioned floor area for each occupancy area and for the building as a whole. The ACM Compliance Documentation must state that the conditioned floor area for spaces within the building DO NOT include the area under permanent floor-to-ceiling height partitions, but the conditioned floor area for the whole building includes the area under these partitions. This conforms with the Standards which define Conditioned Floor Area:

> ... is the floor area (in square feet) of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing conditioned space.

But for internal and enclosed spaces lighting power allotments for the Area Category Method are determined from floor areas:

> ... Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall not be included in any area.

4.3.2.2 Exterior Opaque Surfaces

Description: The ACM Compliance Documentation must include the following information.

1. The conditioned floor area of all conditioned space (i.e., all directly or indirectly conditioned space) must be included in the performance analysis. For a definition of conditioned space, see Section 101(b) of the Standards.

2. All directly or indirectly conditioned volume must be included in the analysis.

3. Every exterior partition of the proposed building must be modeled.

   The Standards define an exterior partition as:

   > ... an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or space that is not enclosed.

4. Every slab-on-grade and underground walls and floors of the proposed building must be modeled.

5. Partitions separating the conditioned space from the courtyard are exterior partitions and must be modeled as such by the ACM.

6. Demising partitions are defined in the Standards as:

   > ... solid barriers that separate conditioned space from enclosed unconditioned space.

   Demising partitions may not be modeled as exterior partitions. They are modeled as interior walls constructed according to the plans and specifications for the building. If the enclosed unconditioned space is not included in the permit, the demising partition must be modeled as an adiabatic partition for both the standard and the proposed buildings.

4.3.2.3 Interior Surfaces

Description: The ACM Compliance Documentation must include the following information.

1. All interior floors must be modeled.

2. Atria are considered indirectly conditioned spaces and partitions separating the conditioned space from atria are interior surfaces.

3. All interzone and interior walls must be modeled as air walls with no heat capacity and ~~U-value~~U-factor of 1 Btu/h-ft^2-^{o}F. The ACM automatically accounts for the heat capacity of all interzone and interior walls by modeling them as light mass.

4.3.2.4 Materials

Description: The ACM Compliance Documentation must explain how the user can simulate different materials as required to make-up different assemblies including *thickness*(feet), *density*(pounds per cubic foot), *specific heat*(Btu per pound per degree F) and *thermal conductivity*(Btu-ft per hour per square foot per degree F).

4.3.2.5 Construction Assemblies

Description: The ACM Compliance Documentation must explain that the user must determine the ~~U-value~~U-factors of assemblies --wood frame, steel frame, masonry, and composite-- and that they must be calculated according to the methods described in Chapter 2.

Note that the ~~U-value~~U-factor requirements for exterior partitions in the Standards include the fixed outside air film assumed in the Nonresidential Manual, but the reference method and other energy analysis computer programs extract this fixed outside air film value and recalculate the outside air film resistance on an hourly basis as a function of wind speed.

4.3.2.6 Absorptance

Description: The ACM Compliance Documentation must describe how the user enters the value for the absorptance.

ACM Compliance Documentation must explain that the ACM user can specify opaque exterior wall or roof/ceiling construction between 0.90 and 0.20 absorptance, and that the program will warn and print an exceptional condition on the PERF-1 whenever the absorptance is less than 0.50 for an opaque exterior partition. The ACM Compliance Documentation must explain what happens if the user does not specify an absorptance. The ACM Compliance documentation must explain to the user how to enter the values for cool roofs and must describe the rating methods and installation criteria that are required for cool roofs.

4.3.2.7 Surface Orientation and Tilt

Description: The ACM Compliance Documentation must describe how the user enters the surface orientation (azimuth) and tilt of each exterior partition.

4.3.2.8 Heat Capacity

Description: The ACM Compliance Documentation must describe to the user how to specify and account for the heat capacity of opaque exterior walls.

The ACM Compliance Documentation must describe to the user how to:

a) Distinguish between an *exterior wall* as defined in the standards and other wall types (e.g., demising wall); and

b) Distinguish between *wood frame*, *steel frame* and *other* wall assemblies.

4.3.2.9 Exterior Doors

Description: The ACM Compliance Documentation must explain how the user enters the construction, materials, orientation, tilt, locations, and areas for exterior doors.

The ACM Compliance Documentation must request the user to specify and account for the heat capacity of all exterior doors in the proposed design. The ACM Compliance Documentation must explain that exterior doors may be grouped together as one area if they have the same (within the tolerance allowed for ACMs) orientation, tilt, construction and materials.

4.3.2.10 Exterior Walls

Description: The ACM Compliance Documentation must describe how the user enters area, and heat capacity of exterior walls.

The ACM Compliance Documentation must describe how to enter the information to determine the Exterior Wall Area as:

Gross Exterior Wall Area - (Vertical Fenestration Area + Door Area)

where the Vertical Fenestration Area is equal to or less than the value explained below.

The ACM Compliance Documentation must request the user to specify and account for the heat capacity of opaque exterior walls in the proposed design, and how to specify and account for the ~~U-value~~U-factor of walls. The ~~U-value~~U-factor of walls may be weight averaged over the area of walls only when the walls are in the same occupancy and system area and have the same azimuth, the walls have the heat capacities within 10% of each other, and the walls are of the same construction type as described in Table 1-H and 1-I of the Standards.

4.3.2.11 Underground Walls

Description: The ACM Compliance Documentation must describe the parameters that users must enter to model underground walls. The ACM Compliance Documentation must require users to separately identify exterior walls separating conditioned space from adjacent earth, and request users to provide sufficient construction/assembly information to simulate walls accurately.

4.3.2.12 Exterior Roofs/Ceilings

Description: The ACM Compliance Documentation must describe how the user enters area, and heat capacity of exterior roofs/ceilings and must describe the standard roof/ceiling.

The ACM Compliance Documentation must explain how the user enters roof/ceiling construction/assembly information to simulate roofs/ceilings accurately.

The ACM Compliance Documentation must describe how the user enters the information to determine the Exterior Roof/Ceiling Area as:

Gross Roof/Ceiling Area - Skylight Area

The ACM Compliance Documentation shall describe how to enter each exterior roof assembly, including construction, orientation and tilt, location and area for all roofs as they occur in the construction documents. Exterior roofs that have the same heat transfer characteristics, mass characteristic and that are in the same occupancy and system areas and are exposed to the same outside conditions may be combined for the purposes of entering the area of the roof assembly. In addition, the ACM Compliance Documentation must describe to the user the acceptable methods of calculating an overall ~~U-value~~U-factor of the assembly, as described in Section 141(c) of the energy efficiency standards.

4.3.2.13 Exterior Raised Floors

Description: The ACM Compliance Documentation must describe how the user enters area, and heat capacity of exterior raised floors and must describe the standard raised floor.

The ACM Compliance Documentation must explain how the user enters raised floor construction/assembly information to simulate raised floors accurately.

The ACM Compliance Documentation shall provide the user with the following information:

The standard design raised floor assemblies are dependent on the HC of the proposed exterior raised floor. The standard design raised floor assemblies are determined as follows:

- HC < 7.0: The standard assembly is a wood framed, lightweight raised floor with a ~~U-value~~U-factor matching the requirement listed in Table 1-H or 1-I of the Standards for wood framed walls and the applicable climate zone.

- If HC $\geq$ 7.0: The standard assembly is two layers:

1. Carpet and pad, R-value = 2.03;

2. 100 lb./cubic foot concrete slab with a thickness such that the total heat capacity of the standard assembly matches the heat capacity of the proposed floor assembly and the overall ~~U-value~~U-factor including carpet and pad matches the applicable value listed in Table 1-H or 1-I of the standards for the applicable climate zone.

4.3.2.14 Concrete Slab Floors on Grade

Description: The ACM Compliance Documentation must describe how the user enters area and heat capacity of concrete slab on grade floors.

The ACM Compliance Documentation must explain how the user enters slab floor construction/assembly information to simulate slab-on-grade floors accurately.

The ACM Compliance Documentation shall provide the user with the information on how to enter slab constructions and areas as they occur in the construction documents.

4.3.2.15 Underground Walls and Floors

Description: The ACM Compliance Documentation must describe the parameters that users must enter to model underground walls and floors. The ACM Compliance Documentation must require users to separately identify floors separating conditioned space from adjacent earth, and request users to provide sufficient construction/assembly information to accurately simulate the heat transfer and heat capacity of the floors.

The ACM Compliance Documentation shall require the user to enter underground floor constructions and areas as they occur in the construction documents.

4.3.2.16 Fenestration Products

Description: The ACM Compliance Documentation must describe how the user enters information about the characteristics of fenestration products in both walls and roof/ceilings that effect the energy use of the building. The features that must be explained in the ACM Compliance Documentation are described in the following sections.

4.3.2.17 Fenestration Orientation and Tilt

Description: The ACM Compliance Documentation must describe how the user enters the actual azimuth (direction) and surface tilt of glazing surfaces in each surface. The user shall be instructed that the azimuth and surface tilt of each glazing surface shall be entered as it occurs in the construction documents rounded off to the nearest whole degree.

4.3.2.18 Fenestration Thermal Properties

Description: The ACM Compliance Documentation must describe that, for each manufactured fenestration product, the user must input the fenestration's overall ~~U-value~~U-factor and SHGC from the NFRC label. The ACM Compliance Documentation must also describe that, for each site assembled or field-fabricated fenestration product, there are ~~two~~ three alternatives for modeling the thermal properties; (1) the user uses the U-factor determined using the NFRC certification for Site-Built Products and the SHGC calculated as shown in Appendix I, (2) the user inputs the default ~~U-value~~ U-factor from Table 1-D and the Solar Heat Gain Coefficient from Table 1-E in the standards; (~~2~~3) the user determines the U-factor from Appendix I and calculates the ~~U-value and~~ SHGC of the fenestration assembly as shown in Appendix I or by using a method approved by the Commission. The ACM Compliance Documentation must also describe that default values are used when no entries are made.

The ACM Compliance Documentation shall explain that the basis of the standards is the appropriate maximum ~~U-value~~U-factor and the Relative Solar Heat Gain or the Solar Heat Gain Coefficient from Tables 1-H and 1-I of the Standards according to occupancy and climate zone.

4.3.2.19 Glazing in Exterior Walls and Shading

Description: The ACM Compliance Documentation must describe how to model heat transfer through all glazed (transparent or translucent) surfaces of the building envelope walls. The user must account for many features of exterior glazing in walls. These features, including all standard and proposed modeling assumptions and inputs, are described in the following sections.

4.3.2.20 Area of Fenestration in Walls and Doors

Description: The ACM Compliance Documentation shall explain how the user must model the exposed surface area of each transparent or translucent surface. Fenestration surfaces include openings in the walls and vertical doors of the building. The ACM Compliance Documentation shall describe how to enter the following:

- *Fenestration Area in Walls and Doors*. For each glazing surface, the user must enter the area of glazing surface associated with a zone. This area is the rough-out opening for the window(s). The areas of fenestration in walls and doors shall only be grouped when they have the same ~~U-value~~U-factor, orientation, tilt, shading coefficient, relative solar heat gain and relationship to shading from exterior devices such as overhangs or side fins. Fenestration in demising walls may not be grouped with fenestration in exterior walls or doors.

- *Display Perimeter*. When the ACM calculates the standard glazing/fenestration area based on the display perimeter, the ACM Compliance Documentation must describe how the user enters parameters for display perimeter. The user must specify a value, in feet, for each zone on each floor or story of the building that abuts a public sidewalk. The value is used as an alternate means of establishing Maximum Fenestration Area in the standard design (Title 24, § 143). As defined in Section 101(b) of the Standards, display perimeter is:

.. the length of an exterior wall in a B-2 occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.

- *Floor Number*. The ACM Compliance Documentation must describe how to determine each floor (story) of a building and how to determine if there is a Display Perimeter associated with each floor (story) of the building, and that a public sidewalk must be surfaced with a material considered acceptable for sidewalks by the local codes, must be readily accessible to the public view. The ACM Compliance Documentation shall explain that the display perimeter is intended for applications where retail merchandise needs to be viewed by the passing public.

The ACM Compliance Documentation must explain that the *Maximum Fenestration Area* is 40% of the gross exterior wall area of the entire permitted space or building that can be occupied, or, if Display Perimeter is specified, the *Maximum Fenestration Area* is either 40% of the gross exterior wall area of the entire permitted space or building, or six feet times the Display Perimeter for the entire permitted space or building, whichever value is greater.

The ACM Compliance Documentation shall describe how to determine the gross exterior wall area.

4.3.2.21 Solar Heat Gain Coefficients of Fenestration in Walls and Doors

Description: The ACM Compliance Documentation shall explain how to determine solar heat gain coefficients and relative solar heat gains for fenestration in walls and doors, as defined in the Standards, and shall explain how and when each is used in modeling the characteristics of buildings. The ACM Compliance Documentation shall describe how and when the user enters solar heat gain coefficient from the Commission default Table or an NFRC label. This solar heat gain coefficient (SHGC) shall apply to the full fenestration area. Fenestration solar heat gain coefficient for each glazing surface shall be entered as it occurs in the construction documents for the building.

The ACM Compliance Documentation shall explain to the user that the basis of the standards are the appropriate maximum RSHG values from Tables 1-H and 1-I of the Standards according to occupancy type, climate zone and orientation. The ACM Compliance Documentation must note that the maximum RSHG is different for north oriented glass; and that, for the purposes of establishing standard design RSHG, north glass is glass in exterior walls and doors facing from 45^{o} west (not inclusive) to 45^{o} east (inclusive) of true north.

For nonresidential buildings, high-rise residential buildings and hotels and motels, approved methods for accounting for the shading effects of site assembled, and field-fabricated fenestration assemblies are the information reported on an approved NFRC label, CEC’s default Table (Table 1-E of the standards), and the value calculated in Appendix I or other ~~by a~~ Commission approved methods. This shading information which includes the effects of glass, framing and mullions applies to the entire window area. Effects such as the buildup of dirt on windows are not considered differential effects between the proposed and standard design which result in energy savings. These effects are intentionally neglected by the reference method and must be considered the same in proposed and standard designs for ACMs.

4.3.2.22 Overhangs

Description: The ACM Compliance Documentation must describe how users model overhangs over windows. The ACM Compliance Documentation must describe how the user enters the following:

- *Overhang projection*. The distance the overhang projects horizontally from the plane of the window.
- *Height above window*. The distance from the top of the window to the overhang.
- *Window height*. The height of the top of the window from the bottom of the window, to which the overhang is applied.
- *Overhang Extension*. The distance the overhang extends past the edge of the window jams.

The ACM Compliance Documentation shall instruct the user to simulate overhangs in the proposed design for each window as they are shown in the construction documents. Overhangs may not be grouped they are applied to windows facing the same direction with the same window height and the overhang has the same overhang projection, height above window, and the overhang is continuous from one window in the group to another.

4.3.2.23 Vertical Shading Fins

Description: The ACM Compliance Documentation shall describe how vertical shading fins are modeled, and will describe the constraints on the use of vertical shading fins. These fins must be attached to the building. Objects that are separate from the building, such as adjacent buildings, may not be modeled as vertical fins.

4.3.2.24 Exterior Fenestration Shading Devices

Description: The ACM Compliance Documentation shall describe how the user enters parameters describing exterior fenestration shading devices. The ACM Compliance Documentation shall describe any restrictions on the parameters. These devices must be attached to the building that the user is modeling for compliance.

4.3.2.25 Window Management

Description: The ACM Compliance Documentation must describe how the ACM models window management and emphasize that this management is an assumption required for all ACMs, not a user option. The assumptions regarding window management include the effects of well-operated interior draperies. The ACM Compliance Documentation shall include the description of the proposed design assumptions that include interior drapes with a *solar heat gain coefficient multiplier* of 0.80.

4.3.2.26 Glazing or Fenestration in Exterior Roofs (Skylights)

Description: The ACM Compliance Documentation must explain how to model heat transfer through all glazing or fenestration (transparent and translucent) in exterior roofs of the building envelope. The user must account for many features of such glazing. These features, including all standard and proposed modeling assumptions and inputs, are described in the following sections.

4.3.2.27 Fenestration Areas of Glazing in Exterior Roofs (Skylights)

Description: The ACM Compliance Documentation shall describe how the user must model the exposed surface area of each transparent or translucent surface, and must describe how the user must enter the proposed design fenestration areas as they are shown in the construction documents. Fenestration surfaces in roofs include openings in roofs and horizontal roof doors of the building.

The ACM Compliance Documentation must explain how the ACM determines the effects of these fenestration areas, include describing that:

1. When the Skylight Roof Ratio in the proposed design is $\leq$ 0.05, the standard design shall use the same fenestration area as on each proposed design exterior roof.

2. When the Skylight Roof Ratio in the proposed design is > 0.05, the ACM shall determine the horizontal fenestration area of the standard design by multiplying the fenestration area in each exterior roof by a fraction equal to:

   $SRR_{standard}/SRR_{proposed}$.

The ~~U-value~~U-factor and solar heat gain coefficients of individual skylights may be combined by area-weighted averaging only if they are not being used for daylighting and if they are in the same zone.

4.3.2.28 Occupancy Types

Description: The Alternative Calculation Method (ACM) Compliance Documentation shall describe the use of the following *occupancy* types for spaces or buildings when lighting plans are submitted for the entire building or when lighting compliance is not performed:

- Commercial and Industrial Work
- Grocery Store
- Industrial and Commercial Storage
- Medical/Clinical
- Office
- Other
- Religious Worship, Auditorium, Convention Center
- Restaurant
- Retail and Wholesale Store
- School
- Theater
- Unknown

The ACM *area occupancy* selection list and Alternative Calculation Method (ACM) Compliance Documentation descriptions must include these *area occupancy* types for spaces when lighting plans are submitted for portions or for the entire building or when lighting compliance is not performed:

- Auditorium
- Auto Repair Workshop
- Bank/Financial Institution
- Bar, Cocktail Lounge and Casino
- Beauty Shop
- Barber Shop
- Classroom
- Commercial/Industrial Storage
- Commercial/Industrial Work - General, High Bay
- Commercial/Industrial Work - General, Low Bay
- Commercial/Industrial Work - Precision
- Convention, Conference and Meeting Center
- Corridor, Restroom and Support Area
- Courtrooms
- Dining Area
- Dry Cleaning (Coin Operated)
- Dry Cleaning (Full Service Commercial)
- Electrical, Mechanical Rooms
- Exercising Rooms and Gymnasium
- Exhibit Display Area and Museum
- Grocery Sales Area
- High-Rise Residential
- Hotel Function Area
- Hotel/Motel Guest Room
- Kitchen and Food Preparation
- Laundry
- Library - Reading Area

- Library - Stacks
- Lobby - Hotel
- Lobby - Main Entry
- Lobby - Office Reception/Waiting
- Locker/Dressing Room
- Lounge/Recreation
- Mall, Arcade and Atrium
- Medical and Clinical Care
- Mixed Occupancy
- Office
- Other
- Religious Worship
- Retail Sales, Wholesale Showroom
- Smoking Lounge
- Theater (Motion Picture)
- Theater (Performance)
- Unknown

The ACM Compliance Documentation must require users to enter the occupancy(s) of each conditioned area or space being modeled. The user should select the occupancy that most closely matches the occupancy specified in Table 2-1 or Table 2-2. The user's occupancy selection should be based on the actual occupancy of the space(s) not on the amount of lighting or other energy use aspects desired. The ACM Compliance Documentation should guide the user on how to determine an occupancy based on occupancy use similarities and limit occupancy lighting information and other occupancy assumptions to references to this Manual or an appendix. By virtue of the categories "other" and "unknown" the occupancy tables are complete and address all possible occupancies. The local enforcement agency (not the ACM user/permit applicant) has the discretion to determine if the user's occupancy choices are reasonable and correct.

If the ACM has an independent occupancy selection for ventilation, the ACM Compliance Documentation must describe how best to select a ventilation occupancy and may describe ventilation assumptions.

The ACM Compliance Documentation is not the forum to argue the validity of *area occupancy* assumptions, nor should the ACM or the ACM Compliance Documentation be written so that either encourages debates about *area occupancy* assumptions or debates about choosing occupancies based on these assumptions. The Commission strongly encourages vendors to reference these assumptions by referring to Chapter 2 of this manual, but these assumptions may also be provided in an appendix to the ACM Compliance Documentation.

4.3.2.29 Mixed Occupancies

Description: The ACM Compliance Documentation shall explain how the user may select *mixed* as the occupancy type when selecting an area occupancy. Area occupancy types may only be mixed when they are all within the same zone, have the same operating schedules and when none of the occupancies includes process loads.

The ACM Compliance Documentation shall describe how the user, if *mixed* is selected as the area occupancy type, enters the following:

1. Total area of the zone,
2. Area and square footage of up to four different area occupancy types.

Note that the areas specified do not include the area of interior partitions for the purposes of determining lighting wattages in accordance with the standards. The reference method assumes that 1% of the floor area is occupied by interior partitions. The ACM Compliance Documentation shall describe how the ACM automatically calculates the sum of the areas for the four different occupancies:

- If the sum of the four different areas is greater than the input total area of the zone, the ACM will abort or ask for corrected input.

- If the sum of the four different occupancies is less than the input total area of the zone, the ACM will assign the occupancy *other* to the additional area needed to equal the input total area.

The ACM Compliance Documentation shall explain that the ACM will assign default assumptions for occupant densities, outside air ventilation rates, lighting loads, receptacle loads and service water heating loads by calculating the area weighted average for each of these inputs, using the areas input by the user. Refer to sections for *lighting*, *ventilation loads* and *process loads* for respective requirements for each of these adjustments.

4.3.2.30 Occupant Loads

Description: The ACM Compliance Documentation shall explain that these values are automatically selected by the ACM based on the occupancy.

4.3.2.31 Receptacle Loads

Description: The ACM Compliance Documentation shall explain that these values are automatically selected by the ACM based on the occupancy type and that the receptacle loads include the process energy produced by equipment that are plugged into receptacle outlets such as personal computers and printers.

4.3.2.32 Process Energy

Description: The ACM Compliance Documentation shall explain that the process energy is limited to the energy produced by equipment whose locations are specified on the plans or other construction documents. The compliance documentation shall clearly explain that the energy generated by plugged-in devices such as office equipment must not be modeled as process energy. The thermal energy from such devices are included in the plug loads shown in Table 2-1 or 2-2.

4.3.2.33 Ventilation

Description: The ACM compliance documentation shall explain that the ventilation level is based on the selected occupancy(s) and cannot be altered by the user. The compliance documentation shall explain that process ventilation may be input by the user for compliance simulations.

The compliance documentation must inform the user that they must justify the need for nonzero tailored ventilation values to the satisfaction of the local enforcement agency.

4.3.2.34 Water Heating

Description: Refer to Section 2.5 , Required Systems and Plant Capabilities for modeling requirements for service water heating systems.

4.3.2.35 Lighting

Description: The ACM Compliance Documentation shall describe how users enter lighting parameters. The documentation shall describe how to enter lighting for each space being modeled. The ACM Compliance Documentation shall request the user to indicate one of the following conditions for the building:

1. *Lighting compliance not performed.* The ACM Compliance Documentation must require the user to enter the occupancy type of each space from Table 2-1 or 2-2 of this manual. The documentation must explain that Table 2-1 may be used even if the building has multiple occupancies.

2. *Lighting compliance performed.* The ACM Compliance Documentation must require the user to indicate whether lighting plans will be submitted for a portion of the building or for the entire building (excluding the residential units of high-rise residential buildings and hotel/motel guest rooms). If lighting plans will be submitted for a portion of the building, the documentation must require the user to select the occupancy type of each space from Table 2-2 of this manual. However, if lighting plans will be submitted for the entire building, the ACM Compliance Documentation must require the user to select the occupancy type of each space from Table 2-1 or 2-2 of this manual. The documentation must explain that for spaces without specified lighting level, the ACM selects the default lighting level from Table 2-2.

The ACM Compliance Documentation must explain that if the *modeled* Lighting Power Density (LPD) is different than the *actual* LPD calculated from the fixture schedule for the building, ACMs shall model the larger of the two values for the compliance run and shall print that value for “Installed Lighting” on PERF-1.

With a specific set of lighting plans that meets the prescriptive tailored lighting requirements and the submittal of the prescriptive *Tailored LPD Summary and Worksheet Forms*, LTG-4, for each HVAC zone with a tailored lighting power entry, the user may choose to enter the Total Allowed Watts from Line 4, Part 1 of LTG-4 as a *Tailored Lighting Allotment* entry for that HVAC zone.

The ACM Compliance Documentation may also request the user to enter the Tailored Lighting Allotment and lighting control credits for each zone when they are applicable and the ACM uses those features.

If a value is input for the Tailored Lighting Allotment, the user shall provide lighting plans that comply with the prescriptive requirements and all necessary Tailored Lighting Forms and Worksheets (LTG-4) documenting the lighting and its justification as part of the compliance documentation.

If a value is input for lighting control credits, the user shall provide documentation that lighting control credits have been used in compliance and provide the lighting Control Credit Watts from Column I for Building Total from LTG-3, Lighting Controls Credit Worksheet. For the performance compliance approach user/applicants may not take credit for lighting controls that would otherwise be required by the Standards, especially by mandatory requirements. The ACM Compliance Documentation must spell out this limitation of lighting control credits. If the ACM allows the user to select from various types of lighting controls, the ACM Compliance Documentation must warn users that the control type selected must be installed in the entire floor area in the space or zone modeled in the program.

4.3.2.36 Enclosed Unconditioned and Semi-Conditioned Spaces

Description: The ACM Compliance Documentation shall describe unconditioned and semi-conditioned spaces and that they are modeled using the same rules. The ACM Compliance Documentation shall also explain that enclosed conditioned and semi-conditioned spaces must be modeled if they are included in the permitted space and that modeling them is optional if they are not part of the permitted space.

If enclosed conditioned or semi-conditioned spaces are not modeled, the demising partition separating the conditioned space from the enclosed unconditioned or semi-conditioned space is modeled as an adiabatic partition (see Section 2.2.2.5).

4.3.2.37 Indirectly Conditioned Spaces

Description: The ACM Compliance Documentation shall explain that ACMs explicitly simulate all indirectly conditioned spaces, and that users may choose to simulate indirectly conditioned spaces as part of the directly conditioned space provided that the total volume and area of indirectly conditioned spaces included are each less than 15% of the total volume and area of the total indirectly and directly conditioned volume and area.

For the purpose of this manual, indirectly conditioned spaces are those which either can be occupied or cannot be unoccupied.

The requirements for each of these three cases are documented below.

Indirectly Conditioned Spaces Included in Directly Conditioned Space

The ACM Compliance Documentation shall describe how the user enters this space. The space must use the same configuration and occupancy characteristics as occurs in the construction documents, including envelope performance, occupancy characteristics and lighting levels.

Indirectly Conditioned Spaces that can be occupied and Explicitly Modeled

The ACM Compliance Documentation must describe how the user must explicitly identify indirectly conditioned space which can be occupied.

Indirectly Conditioned Spaces that cannot be occupied and Explicitly Modeled

The ACM Compliance Documentation must describe how the user must explicitly identify indirectly conditioned space which cannot be occupied. The ACM Compliance Documentation must instruct the user to specify the amount of light heat to be rejected to this space.

4.3.2.38 Light Mass

Description: The ACM Compliance Documentation shall describe how users enter parameters to approximate the mass effects of all interior partitions and furniture. When the ACM allows the user to enter information on lightweight mass, the ACM Compliance Documentation shall describe how to determine appropriate entries and restrictions on user entries for the spaces described below:

- *Directly Conditioned and Indirectly Conditioned Space Which Can be Occupied:* The reference method models lightweight mass through the use of "heavy" furniture weighing 80 pounds per square foot of floor area. In this method, there is an 85% chance that sunlight will fall upon furniture as opposed to the floor.

- *Indirectly Conditioned Spaces Which Cannot be Occupied:* For these spaces the reference method models lightweight mass by using a light furniture category of 30 pounds per square foot in DOE 2.1 to generate the lightweight standard weighting factors for these spaces.

4.3.3 Required Systems and Plant Capabilities

The ACM Compliance Documentation must describe the application of the energy source conversion factor and any features of the program for which the user must consider this factor.

4.3.3.1 Thermal Zones

Description: The ACM Compliance Documentation must describe the number of thermal zones (a minimum of fifty) that the ACM is capable of modeling and the minimum control capabilities that must be included in each of these zones.

As described in Chapter 2, if a proposed building design has twenty thermostats or less the ACM Compliance Documentation must require the user to model the same number of zones as there are independent thermostats. Hence zones may only be combined when there are more than twenty (20) HVAC zones in a proposed building design. The methods of combining thermal zones shall be consistent with the definition *ZONE, SPACE CONDITIONING* in Section 101(b) of the Standards. This definition states:

> ZONE, SPACE CONDITIONING is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in 144(b)3 or 150(h), as applicable, can be maintained throughout the zone by a single controlling device.

The ACM Compliance Documentation must explain the characteristics that will lead to zones being similar, so they may be combined into one zone for modeling purposes, and the characteristics that will lead to the zones being dissimilar. An example of similar zones may be central core areas on multiple floors of a multi-story building when they are served by the same system or systems of the same category. See Section 4.3.3.19 for combining like systems. An example of dissimilar zones may be a perimeter area on one facade of a building, part of which includes glazing and part of which has no glazing. The conditions in these two areas are sufficiently dissimilar that the areas should be treated as two zones (if they are independently controlled) even though they are on the same floor and facing the same orientation.

The ACM Compliance Documentation should also emphasize that the distribution of heating and cooling must be well balanced across any area that is to be considered as one zone.

Zoning the building for compliance calculations must be consistent with the actual zoning of the building if the actual zoning is known at the time of the analysis. If there are more actual zones than the program is capable of modeling, actual zones may be merged together for compliance purposes, as long as it can be established that the actual zones being grouped together for compliance are *thermodynamically similar* such that physical comfort could be maintained by a single thermostat or HVAC-controlling device/sensor.

The ultimate test is to use non-coincident load calculations to show that actual zones grouped together for compliance calculations have the same or similar peak heating and cooling load profiles. This is done with a design load calculation which considers the peak load by month and hour.

Typically, physical zones which have the same or similar glazing orientation(s), the same or similar glazing area to floor area and the same occupancy types will be thermodynamically similar since, for example, they experience their peak cooling loads at the same hour. These zones can be merged together for compliance calculations.

The compliance documentation should tell the ACM user if the standard design uses exactly the same zoning in the proposed building design as the reference method does.

The ACM Compliance Documentation shall also describe how to zone a building that does not include an HVAC system in the design. Any building or separate permitted space smaller than 2500 ft^2 in conditioned floor area without an HVAC system or design may be modeled as having only a single HVAC zone. However, for buildings or permitted spaces 2500 ft^2 and greater, each floor of the building shall be divided into multiple thermal zones according to the following procedure:

1. Determine the ratio (R) of the floor's total conditioned area to the gross exterior wall area associated with the conditioned space.

2. For each combination of occupancy type and exterior wall orientation create a perimeter zone. The floor area of each perimeter zone shall be the gross exterior wall area of the zone times R or 1.25, whichever is smaller.

3. Model the exterior space adjacent to each wall orientation as a separate exterior zone. Spaces adjacent to walls which are within 45 degrees of each orientation shall be included in the zone belonging to that orientation.

4. For cases where R is greater than 1.25, create an interior zone for each occupancy type. For each occupancy type, the floor area of the interior zone shall be the total area less the floor area of the perimeter zones created in paragraphs 2 and 3 above.

5. Prorate the roof area and the floor area among the zones according to the floor area of each zone. Prorate the roof and floor areas among the perimeter zones created in paragraphs 2 and 3 above according to the floor area of each exterior zone.

6. Assign skylights to interior zones. If the skylight area is larger than the roof area of the interior zone, then the skylight area in the interior zone must be equal to the roof area in the interior zone and the user must prorate the remaining skylight area among the perimeter zones based on the floor area.

7. If the area of the zone is less than 300 ft^2, combine it with its adjacent zone of the same occupancy type and zone type (interior or exterior).

8. Courtyards are considered outside or ambient air. Walls, floors, and roofs separating conditioned spaces from courtyards are exterior walls, floors, and roofs. Create an exterior zone for each wall orientation separating the conditioned space from the courtyard. The user shall not combine these exterior zones with other exterior zones even if their exterior walls have the same orientation.

9. Model spaces adjacent to demising walls as interior zones. Combine these zones with other interior zones within the same occupancy type.

10. Ignore all interior walls and model partitions separating thermal zones as air walls with ~~U-value~~U-factor of 1.0 Btu/h-ft^2-°F.

Since the Commission considers a larger number of modeled HVAC zones to be a more accurate representation, the ACM Compliance Documentation must inform ACM users that the local enforcement agency may (at its own discretion) require the applicant to model additional HVAC zones.

4.3.3.2 Primary Systems

Description: The ACM Compliance Documentation must include a list of the primary systems that the ACM can model. The ACM Compliance Documentation shall explain each required input parameter that is needed to describe each primary system, and shall explain how the user determines the appropriate input for any proposed design that will use the input.

The ACM Compliance Documentation shall also describe any constraints on each primary system, such as maxima, minima, ranges, or specific design applications.

4.3.3.3 Cooling Equipment

Description: The ACM Compliance Documentation must describe how the user must enter parameters that describe cooling equipment type, efficiency, capacity, or other parameters that are required to model the operation of the cooling system. The ACM Compliance Documentation must describe to the user how to enter the number and names of zones served by the HVAC system so that the ACM may determine the use of single or multizone systems and so that the user correctly assigns each zone to an HVAC system serving it. The ACM Compliance Documentation must describe how the user must enter parameters that determine the required efficiency of the equipment, the efficiency descriptor that must be used, and, when applicable, heat transfer fluid.

The ACM Compliance Documentation must describe each type of cooling equipment that the ACM is capable of modeling, and any constraints, such as maxima, minima, or ranges, that the user must consider when modeling specific equipment.

4.3.3.4 Heating Equipment

Description: The ACM Compliance Documentation must describe how the user must enter parameters that describe heating equipment type, efficiency, capacity, or other parameters that are required to model the operation of the heating system. The ACM Compliance Documentation must describe how the user must enter parameters that determine the required efficiency of the equipment, the efficiency descriptor that must be used, and , when applicable, the part load ratio and heat transfer fluid.

The ACM Compliance Documentation must describe each type of heating equipment that the ACM is capable of modeling, and any constraints, such as maxima, minima, or ranges, that the user must consider when modeling specific equipment.

4.3.3.5 Standard Design System Selection

Description: The ACM Compliance Documentation must include a description of the required user input for:

- Building Type
- System Type (especially Single Zone or Multi-Zone)
- Heating Source
- Cooling Source

so that the ACM and the reference method can properly determine the Standard HVAC System and Plant in the standard building design.

The purpose of the ACM Compliance Documentation is to explain the proper use of the ACM for compliance purposes rather than the detailed procedures and assumptions of the reference method already described in this manual or in the ACM's technical documentation. The ACM Compliance Documentation shall NOT describe the standard design system types that are used to generate the standard design budget, and shall NOT describe which system types in the standard design must be used as the basis for comparison to proposed design system types. Such information may be included as a separate Technical Engineering Document for the ACM.

The ACM Compliance Documentation shall describe any restrictions or limitations that the user should apply when entering parameters that describe the systems.

4.3.3.6 Cooling Efficiency of DOE Covered Air Conditioners

Description: The ACM Compliance Documentation shall describe how the user determines the proper efficiency descriptor for air conditioners that are **Covered Consumer Products**, and how the user must enter these descriptors into the ACM.

4.3.3.7 Cooling Efficiency of Packaged Equipment not Covered by DOE Appliance Standards

Description: The ACM Compliance Documentation shall describe how the user determines the proper efficiency descriptor for packaged air conditioners that are **not Covered Consumer Products**, and how the user must enter these descriptors into the ACM.

4.3.3.8 Efficiency of Cooling Equipment Included in Built-up Systems

Description: The ACM Compliance Documentation shall describe the required user input parameters for:

- Type of central water chilling plant equipment,
- The number of central chilling units,
- The capacity of each unit,
- The electrical input ratio of each central chilling unit
- The type of refrigerant to be used in each chilling unit.

4.3.3.9 Heating Efficiency of DOE Covered Equipment

Description: The ACM Compliance Documentation shall describe how the user determines the proper efficiency descriptor for heating equipment that are **Covered Consumer Products**, and how the user must enter these descriptors into the ACM.

4.3.3.10 Heating Efficiency of Equipment Not Covered by DOE Standards

Description: The ACM Compliance Documentation shall describe how the user determines the proper efficiency descriptor for heating equipment that are **not Covered Consumer Products**, and how the user must enter these descriptors into the ACM.

4.3.3.11 Electric Motor Efficiency

Description: The ACM Compliance Documentation shall explain that the motor efficiency must be determined as established in accordance with NEMA Standard MG1.

4.3.3.12 ARI Fan Power

Description: The ACM Compliance Documentation shall describe how users enter the fan power for each system type.

4.3.3.13 Process Fan Power

Description: The ACM Compliance Documentation shall explain that fans used exclusively for process must not be modeled in the compliance run. The Compliance Documentation shall describe how users must subtract out the portion of fan power used for process if the fan serves a process as well as conditioning the space.

4.3.3.14 Fan System Operations

Description: The ACM Compliance Documentation shall describe the required schedules that are used for fan system operation. The documentation must explain how the ACM models intermittent fan operation for the residential units of high-rise residential buildings and hotel/motel guest rooms.

4.3.3.15 Fan Volume Control

Description: The ACM Compliance Documentation shall describe the types of fan volume control that are available to the user, and any restrictions on the use of each fan system.

4.3.3.16 Design Fan Power Demand

Description: The ACM compliance documentation shall describe how the user enters parameters describing the fan power. These parameters shall include the design brake horsepower, the design drive/motor efficiency, and the design motor efficiency, all at peak air flow rate. The parameters shall be provided for each supply and each return fan. The compliance documentation shall explain that if the user does not input the above required parameters, the ACM shall assume that no mechanical compliance will be performed and shall model the default mechanical system.

ACMs may combine return fans with the supply fan if and only if the controls are of the same type. For example, ACMs may combine fans if they all have variable speed drive control or if they all are constant volume fans.

4.3.3.17 Air Economizers

Description: The ACM Compliance Documentation shall describe when economizers are required and when they are used as the basis of the performance compliance. The ACM Compliance Documentation shall also describe how to enter parameters describing the economizer and its method of operation. The ACM Compliance Documentation shall describe any restrictions on the modeling of economizers by the ACM.

4.3.3.18 Modeling Default Heating and Cooling Systems

Description: The ACM Compliance Documentation shall explain that the ACM automatically selects and models default heating and cooling systems identical to the standard systems defined in Section 2.4.2.4 (Standard Design Systems) for the following conditions:

1. *Mechanical compliance not performed.* The Compliance Documentation shall describe what parameters must be entered by the user to allow the ACM to select the proper default heating and cooling systems such as the building type and the number of thermal zones. The documentation must explain the guidelines for zoning a building as described in Section 4.3.3.1 of this manual.

2. *Mechanical compliance performed with no heating installed.* The Compliance Documentation shall describe that the ACM automatically models the default heating system for spaces with no installed heating or spaces which use the existing heating system. The documentation shall also describe what parameters must be entered by the user to allow the ACM to select the proper default heating system such as the building type and the number of thermal zones in the permitted space.

3. *Mechanical compliance performed with no cooling installed.* The Compliance Documentation shall describe that the ACM automatically models the default cooling system for spaces with no installed cooling or spaces which use the existing cooling system. The documentation shall also describe what parameters must be entered by the user to allow the ACM to select the proper default cooling system such as the building type and the number of thermal zones in the permitted space.

4.3.3.19 Combining Like Systems

Description: ACMs must explain that users may model like systems together as one system provided the systems serve the same thermal zone or the thermal zones served by the individual units are similar and are being combined. The characteristics that leads to zones being similar are described in Section 4.3.3.1. The equipment being combined must also be all of the same category.

Multiple units of the same type fall into the following categories:

Cooling Equipment

- Single package < 65,000 Btuh
- Split system < 65,000 Btuh
- All package ≥ 65,000 and ≤ 75,000 Btuh
- All package > 75,000 and < 135,000 Btuh
- All package ≥ 135,000 and ≤ 760,000 Btuh

- Condensing Units, Air-Cooled ≥ 135,000 Btuh
- Condensing Units, Water or Evaporatively Cooled ≥ 135,000

- Water Chillers, Water-Cooled < 150 tons
- Water Chillers, Water-Cooled ≥ 150 and < 300 tons
- Water Chillers, Water-Cooled ≥ 300 tons, ozone safe refrigerants
- Water Chillers, Water-Cooled ≥ 300 tons, non-ozone safe refrigerants

- Water Chillers, Air-Cooled < 150 tons
- Water Chillers, Air-Cooled ≥ 150 and < 300 tons
- Water Chillers, Air-Cooled > 300 tons

Heating Equipment

- Heat pumps, single package < 65,000 Btuh
- Heat pumps, split system < 65,000 Btuh
- Heat pumps, all ≥ 65,000 and ≤ 75,000 Btuh

- Heat pumps, all > 75,000 and < 135,000 Btuh
- Heat pumps, all ≥ 135,000 Btuh

- Boilers, gas fired < 300,000 Btuh
- Boilers, gas fired ≥ 300,000 Btuh
- Boilers, oil fired < 225,000 Btuh
- Boilers, oil fired ≥ 225,000 and < 300,000 Btuh
- Boilers, oil fired ≥ 300,000 Btuh
- Boilers, residual oil fired, < 300,000 Btuh
- Boilers, residual oil fires, ≥ 300,000 Btuh

- Furnaces, all fossil fuel fired < 225,000 Btuh
- Furnaces, gas fired ≥ 225,000 Btuh
- Furnaces, oil fired ≥ 225,000 Btuh

Fan Systems

- Constant volume, FPI ≤ 0.8 watts/cfm
- Constant volume, FPI > 0.8 watts/cfm
- Variable volume, ≤ 25 HP, FPI ≤ 1.25 watts/cfm
- Variable volume, ≤ 25 HP, FPI > 1.25 watts/cfm
- Variable volume, > 25 HP, FPI ≤ 1.25 watts/cfm
- Variable volume, > 25 HP, FPI > 1.25 watts/cfm

Water Heaters

- Electric storage
- Electric instantaneous
- Gas storage ≤ 75,000 Btuh
- Gas storage > 75,000 Btuh
- Gas instantaneous

4.3.3.20 System Supply Air Temperature Control

Description: The ACM Compliance Documentation shall describe the control strategies that the ACM can model, and shall describe the parameters that the user must enter to model these strategies. At a minimum, the ACM Compliance Documentation must describe strategies for constant supply air temperature when heating or cooling, and outdoor air reset for the cooling supply air temperature.

4.3.3.21 Zone Terminal Control

Description: The ACM Compliance Documentation must describe when the user must enter zone terminal control parameters, and how the user must enter parameters for:

1. Variable air volume
2. Minimum box position
3. (Re)heating Coil
4. Hydronic Heating

5. Electric Heating

The ACM Compliance Documentation shall explain the criteria for minimum box position for variable volume systems.

4.3.3.22 Pump Energy

Description: The ACM Compliance Documentation shall explain that the ACM accounts for the pump energy for the hot water, chilled water, and condenser water piping systems. For multiple pump systems, the documentation shall explain how to calculate the weighted average pump efficiency for the system.

The ACM Compliance Documentation must show the default values for the hot water, chilled water, and condenser loop piping systems.

4.3.3.23 Chiller Characteristics

Description: The ACM Compliance Documentation shall describe how the user enters chiller parameters that are required in the ACM, the chiller options that are available within the ACM, and the constraints on these parameters. The documentation must also show default values for the chiller options.

4.3.3.24 Performance Curves for Electric Chillers

Description: The ACM Compliance Documentation shall explain that the ACM allows modeling custom performance curves for electric chillers. The documentation must describe the input requirements for calculating the regression constants for the chiller performance. The documentation must also explain that the ACM uses default performance curves if the user chooses not to make any entries.

4.3.3.25 Air-Cooled Condensers

Description: The ACM Compliance Documentation shall describe how the user is allowed to account for the characteristics of air-cooled condensers.

4.3.3.26 Cooling Towers

Description: The ACM Compliance Documentation shall describe how the user enters cooling tower parameters that are required in the ACM, the cooling tower options that are available within the ACM, and the constraints on these parameters. The documentation must also show default values for the cooling tower options.

4.3.3.27 Service Water Heating

Description: The ACM Compliance Documentation shall describe the parameters that the user must enter to describe the water heating system, the efficiency of each water heater and the load that the water heater must meet. The ACM Compliance Documentation must also describe that the user must assign the load to individual water heaters when either more than one water heater is used to meet the load on one system, or when multiple systems are used in a building. When more than one water heater is used to meet the load for one system, the load distributed to each water heater in accordance with the following equation.

$$LOAD_k = LOAD_T \times \frac{OUTPUT_k + 453.75 \times VOL_k}{\sum_{m=1}^{n}(OUTPUT_m + 453.75 \times VOL_m)}$$

Equation 4.3.1

Where:

$LOAD_k$ = Portion of total load met by water heater k.

$LOAD_T$ = Total water heating load of system in Btu/hr.

$OUTPUT_m$ = Full load output capacity of water heater m.

VOL_m = Actual storage capacity in gallons of water heater m.

4.3.3.28 Duct Efficiency Calculation

Description: The ACM Compliance Documentation shall describe the parameters that the user must enter to describe the air distribution system when Chapter 7 and Appendix G are used in conjunction with verified duct sealing.

4.4 Optional Modeling Capabilities

The ACM Compliance Documentation shall provide detailed instructions on the documentation needed for optional capabilities, including instructions on how the ACM models the capability, which required capability will be used as the basis of the standard design for the capability, and any restrictions on the input values for the capability.

4.4.1 Optional Compliance Capabilities

The ACM Compliance Documentation shall describe how users model additions, alterations, and additions plus alterations to the existing building.

4.4.1.1 Additions Performance Compliance

Description: An addition is treated similar to a new building in the performance approach. Since both new conditioned floor area and volume are created with an addition, all systems serving the addition will require compliance to be demonstrated. This means that either the prescriptive or performance method can be used for each stage of the addition's construction.

Addition Only

Additions that show compliance with the performance method independent of the existing building, must meet the requirements for new buildings. *Standards* §149(a)2 states that the *envelope* and *lighting* of the addition, and any newly installed *space conditioning* or *service water heating* system serving the addition, must meet the mandatory measures and the energy budget determined in the performance run.

The user must input all envelope, lighting and HVAC data associated with new conditioned space. If the HVAC zone serving the addition includes a portion of the existing building, pro-rate the capacity, fan power and cfm of the system serving the addition according to the design loads in the addition as compared to the loads in the whole zone.

If the permit is done in stages, the rules for each permit stage apply to the addition performance run. If the whole addition is included in the permit application, the rules for whole buildings apply.

Existing plus Addition

Additions may also show compliance by demonstrating that efficiency improvements to the existing building offset decreased addition performance. *Standards* §149(a)2. states that the envelope and lighting of the addition, and any newly installed space conditioning or service water heating system serving the addition, must meet the mandatory measures just as if it was an addition only. It also allows the applicant to improve the energy efficiency of the existing building so that it meets the energy budget that would apply to the entire building, if the existing building was unchanged, and the addition complied on it own.

This analysis includes a calculation of the energy use of the existing building. In this approach, the following steps must be followed:

a) Collect and document all information on the existing building before the addition and/or remodel.

b) Analyze the energy performance of the existing building before any changes take place.

c) Analyze the energy performance of the existing building plus the addition, including any changes to the existing building.

d) The estimated energy use of the modified existing building plus the addition must be less than the estimated energy use of an addition that complies with the prescriptive standards and the estimated energy use of the original existing building.

When using this compliance approach, it is important to take into account all changes in fenestration, especially windows and skylights which are removed from or added to the existing house as part of the remodel. Credit may be gained in this context by insulating previously uninsulated parts of the building envelope.

It is important to note that the term "entire building" means the ensemble of all enclosed space in a building, including the space for which a permit is sought, plus all conditioned and space within the structure.

To show compliance with this approach you need to follow the instructions in the computer program's compliance supplement.

When using this compliance approach it is important to take into account all changes in the buildings features that are removed from or added to the existing building.

Documentation of the existing buildings features is required to be submitted with the permit application if this method is used.

4.4.1.2 Alterations Performance Compliance

Description: Using the performance approach for the alteration is similar to demonstrating compliance with an addition.

Alteration Only

Altered spaces that show compliance with the method independent of the existing building, must meet the requirements for new buildings. *Standards* §149(b)2 states that the and lighting of the alteration, and any newly installed conditioning or service water heating system serving the alteration, must meet the mandatory measures and the permitted space alone shall comply with the energy budget determined using an alternative computer program.

If the permit is done in stages, the rules for each permit stage apply to the alteration performance run.

If all the alterations' components, including the envelope, mechanical and lighting systems, are included in the permit application, the rules for whole buildings apply.

Existing with Alteration

Alterations may also show compliance by demonstrating that efficiency improvements to the existing building offset decreased performance of the permitted space. *Standards* §149(a)2. states that the envelope and lighting of the alteration, and any newly installed space conditioning or service water heating system serving the alteration, must meet

the mandatory measures just as if it was an alteration only. It also allows the applicant to improve the energy efficiency of the existing building so that it meets the energy budget that would apply to the entire building, if the existing building was unchanged, and the permitted complied on its own.
To show compliance with this approach you need to follow the instructions in the computer program's compliance supplement.

When using this compliance approach it is important to take into account all changes in the buildings features that are removed from or added to the existing building as a part of the alteration.

Documentation of the existing buildings features is required to be submitted with the permit application if this method is used.

4.4.1.3 Alternate Performance Compliance Method

Description: Any addition, alteration or repair may demonstrate compliance by meeting the applicable requirements for the entire building. Using this method, the entire building could be shown to comply in permit stages or as a whole building. The rules for new buildings, and both permit stage compliance and whole building compliance would apply.

Documentation of the existing buildings features is required to be submitted with the permit application if this method is used.

4.4.2 Optional Loads Capabilities

4.4.2.1 Conditioned Floor Areas

Description: The ACM Compliance Documentation must describe how the user determines and enters the conditioned floor area for each occupancy area and for the building as a whole. The ACM Compliance Documentation must state that the conditioned floor area for spaces within the building DO NOT include the area under permanent floor-to-ceiling height partitions, but the conditioned floor area for the whole building includes the area under these partitions. This conforms with the Standards which define Conditioned Floor Area:

> ... is the floor area (in square feet) of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing conditioned space.

But for internal and enclosed spaces lighting power allotments for the Area Category Method are determined from floor areas:

> ... Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall not be included in any area.

4.4.2.2 Footprint Areas

Description: The ACM Compliance Documentation must describe how to determine and describe building footprint(s). The description must include the following information.

1. All directly or indirectly conditioned volume are included in the footprint area.

2. All building interior cavities (atria and courtyards) are included in the footprint area.

3. Floors have the same footprint if:

    a) They have identical plan views, i.e., having the same shape and area after including all building's interior cavities,

    b) They have identical floor to ceiling distances, and

    c) They have identical window patterns.

4. Floors having identical footprints may be modeled using Floor Multipliers or an equivalent technique. The user shall model the lowest floor having that footprint and the ACM shall duplicate these features for all floors of the building having that footprint.

4.4.2.3 Geometry of Building's Interior Cavities

Description: The ACM Compliance Documentation must describe how to model building's interior cavities such as atria and courtyards. The description must include definitions of atria and courtyards and describe the difference between them, information about when the cavity is modeled as a conditioned space and when it is modeled as outside, and how to model the partitions separating the conditioned space from the building's interior cavities.

4.4.2.4 Self Shading

Description: The ACM Compliance Documentation shall describe how the user enters parameters describing building self shading. The ACM Compliance Documentation shall describe any restrictions on the parameters. Only parts of the building that are included in the permit for which the building is being modeled are allowed to be included in the building self shading. Adjacent buildings or existing buildings may not be modeled as building self shading. These building parts that are providing shading must be a contiguous building with the conditioned area of the portion of the building that is being analyzed for compliance. Building self shading may shade either the glazing or opaque surfaces.

4.4.2.5 Lighting Controls

Description: The ACM Compliance Documentation must describe how to enter lighting controls, how to account for installed lighting and how to document the location and quantity of lighting on the appropriate forms.

4.4.2.6 Light Heat To Zone

Description: The ACM Compliance Documentation must describe how to enter the light heat that goes to the zone and to the return air, how to account for the light energy, and how to document the type, location, and quantity of lighting fixtures for which this option is being modeled on the appropriate forms.

4.4.3 Optional Systems & Plant Capabilities

4.4.3.1 System Areas

Description: The ACM Compliance Documentation must describe the number of system areas (a minimum of fifteen) that the ACM is capable of modeling. System areas may only be combined when there are more than fifteen (15) system areas in a proposed building design.

The ACM Compliance Documentation must explain the characteristics that will lead to system areas being similar, so they may be combined into one system area for modeling purposes, and the characteristics that will lead to the system areas being dissimilar. An example of similar system areas may be central core areas on multiple floors of a multi-story building. An example of dissimilar system areas may be a perimeter area on one facade of a building, part of which includes glazing and part of which has no glazing. The conditions in these two areas are sufficiently dissimilar that the areas should be treated as two system areas (if they are independently controlled) even though they are on the same floor and facing the same orientation.

4.4.3.2 Thermal Zones

Description: ACMs shall explain that thermal zoning is performed by the program during the compliance run and no user input is required.

4.4.3.3 Optional Systems

Description: The ACM Compliance Documentation shall include descriptions of all the optional systems that the ACM is capable of modeling. Optional systems that are allowed are described in Section 3.5.2. The ACM Compliance Documentation shall provided a detailed description of each optional system that is modeled, shall describe the system type that is used as the comparative standard design as described for minimum system capabilities, and will describe any restrictions on the capabilities of each optional system.

The ACM Compliance Documentation shall require the user of the ACM to provide manufacturers data, plans and specifications to document the assumptions used for each optional system.

4.5 Vendor Defined Optional Capabilities

Optional capabilities that are not described in this manual may be proposed by ACM vendors. These Capabilities may be approved by the Commission when sufficient documentation is provided to justify that the capability achieves the estimated energy savings. Once the Commission has accepted a vendor defined optional capability, the ACM Compliance Documentation must include a description of how the user enters the appropriate parameters for the capability, a description of the documentation that must be provided when using the capability, and a description of any restrictions that must be applied when using the capability.

4.6 Compliance Forms

A chapter or section must focus on how standard compliance forms are automatically generated and how to get diagnostic output when a building fails to comply (since compliance forms cannot be generated when a building fails to comply.) Alternative Calculation Methods (ACMs) must print out the standard compliance forms with essentially the same format and layout as those in Chapter 2 or the Appendices. Mention should be made of:

- The requirement to document Tailored Lighting Allotments with lighting plans and prescriptive LTG-3 forms for each HVAC zone;
- The requirement to document Tailored Ventilation and/or Process Loads;
- The requirement to complete other forms for submittal (e.g., ENV-3) when applicable;
- The requirement to document the zoning of the building if the zoning is not evident on the plans; and,
- The requirement to document Exceptional Conditions, Special Features and Remarks, on the Certificate of Compliance (PERF-1) when applicable.

At least one sample of each compliance form must be included. It is recommended, but not required, that the ACM Compliance Documentation contain several sample variations of each compliance form as needed to illustrate different compliance scenarios and input types (see Appendices below).

4.7 Appendices

Appendices may be an appropriate way to handle sources of information that are not crucial in explaining the basic functioning of the program for compliance. For example:

- An appendix may contain variations of compliance forms as described above.
- An appendix may include a series of construction assembly (ENV-3) forms to aid the ACM user.
- An appendix may reprint important sections of the *Nonresidential Manual* or this manual that are crucial to modeling buildings correctly for compliance with the ACM.

CHAPTER 5. Minimum Conformance Tests

This chapter explains the methods used to test the modeling and input capabilities of Alternative Calculation Methods (ACMs) relative to the reference program, DOE 2.1E, and the custom budget procedure described in this manual. The ACM must be able to accept all required inputs but it need not be capable of modeling all features as long as it automatically fails proposed designs with features beyond its accurate modeling capabilities. For example, a simplified calculation method modeling only single zone HVAC systems could be approved if it automatically fails proposed designs that enter multizone HVAC systems for the proposed design by an appropriate margin. For ACMs with limited capabilities, the vendor must inform the users that the ACM is not capable of modeling certain capabilities and for compliance purposes the ACM automatically fails any proposed building design that uses inputs exclusive to said capabilities. While most of the tests are performed in three climate zones, other climate zones are used for some of the tests. There are a total of 76 specified tests.

All the runs described in this chapter must be performed with the ACM, and run results must be summarized on the forms contained in Appendix A.

5.1 Overview

ACMs calculate six components of annual building source energy use:

1. Lights
2. Space cooling
3. Space heating
4. Indoor fans
5. Receptacles
6. Service water heating

To test the minimum ACM capabilities for modeling annual source energy, it is necessary to perform a series of computer runs. Each computer run represents a systematic variation of one or more features that affects total source energy use. Some of the parametric runs are performed in several climate zones for more than one prototype building. Most, however, are designed for only one prototype in just one or two of the climate zones.

For an ACM to be approved, the criteria described in Section 5.1.4 must be met. This criteria compares the energy use differences, calculated using the ACM, to the energy use differences calculated using the reference calculation method. The energy use difference or compliance margin for each of these is the difference between ***any*** *simulated proposed building design energy budget and the standard design's energy budget. The standard design is the corresponding simulated building if the design had included the features required by the prescriptive standards. For this comparison the* ***same*** *proposed building and its corresponding standard building must be used for the ACM as is used with the reference program. These criteria must be met for all (each and every one) of the tests described in this manual where the reference method uses DOE 2.1E inputs and files similar to those described in the example input files shown in the appendices and the tests described in this chapter to model the proposed and standard buildings.*

The ACM vendor is responsible for running the tests for the ACM that is being submitted for approval. The vendor shall provide documentation showing the reasons and engineering justification for any inputs, to the vendors program, that, upon review, appear to produce erroneous or misleading results. If the vendor believes that the reference program results presented in this manual and its supplement do not reflect the proper procedures described in Chapters 2 and 3 of this manual and (where not otherwise specified herein) the nonresidential energy efficiency standards, the vendor may also submit runs and results for the reference program, DOE 2.1E as an alternative to the results published in this manual. The vendor must thoroughly justify and document the reasons for the differences in the reference program inputs and results from the inputs and results presented in this Manual and the Supplement. If the Commission accepts the vendor's justification, the ACM may be approved based on the vendor's results for some of the tests.

5.1.1 Base Case Prototype Buildings

Descriptions of four theoretical prototype buildings are summarized in the following paragraphs. The letter is used as part of the label for each computer run.

A This prototype is a theoretical one-story building measuring 30 by 75 feet and is 12 feet high. Glass exists in a continuous band around the entire building perimeter with its bottom edge 2.5 feet above the floor. The building has a single thermal zone.

B This prototype is a theoretical two-story building measuring 60 by 60 feet and is 24 feet high. Glass exists in a mostly continuous band around the entire building perimeter on each floor with its bottom edge at 2.5 feet above the floor. Most tests using prototype B have no interior zones. For all practical purposes the applicant may assume adiabatic, massless walls facing the interior zones. The building has four thermal zones per floor that are 15 feet deep. In most of the tests using this prototype the interior zones have been purposely removed to increase the sensitivity to envelope measures using separate orientations and wall types for each HVAC zone. These separate zones are more sensitive to the measures examined than an envelope- dominated single zone which can mask orientation and individual wall effects. The sensitivity to HVAC sizing methods is also increased when this prototype is envelope dominated.

In some tests to measure internal energy use differences or economizer cycle sensitivity, the 30 by 30 foot interior space becomes two conditioned zones (one on each floor) served by a separate package variable air volume system. In these cases there are five thermal zones per floor.

C This prototype is a six-story building measuring 60 by 60 feet by 66 feet high. Glass exists in a mostly continuous band around the entire perimeter of the building on each floor with its bottom edge 2.5 feet above the floor. The building has a total of fifteen thermal zones: Five on the first floor, five on the middle floors and five on the top floor.

D This prototype is like a tenant improvement space in that it has only two exterior walls with two demising "party" walls with R-11 insulation between steel framing members. The "party" walls are each adjacent to an unconditioned space of the same dimensions as the conditioned space (viz. 20 feet wide, 60 feet deep and 12 feet high). These party walls have nominal 2x4 steel stud framing with R-11 insulation between framing members and 0.5" sheetrock on either side [CONS = DEMISING]. The unconditioned space has three other exterior walls that use the W1A wall-type construction. The roof/ceiling of the unconditioned spaces has R-11 insulation between 2x6 wood framing members [RF1B]. The D prototype building (both conditioned and unconditioned spaces) is built slab-on-grade. The unconditioned spaces are modeled using a slab without carpet or pad and with no slab edge insulation. For the conditioned space, the nominally "west" back wall is heavyweight concrete with no windows and a wood door and the "east" front wall is a steel-framed wall with glazing. The space is 20 feet wide and 60 feet deep and has a height of 12 feet. The glazing begins at ground level but varies in height from 4.8 to 6 feet. Tests with this prototype use overhangs and skylights and rotate the whole building geometry.

The base case prototype buildings have the same geometry and zonation in all climate zones, although prototype B may have ten (10) zones rather than eight (8) for some of the tests. Default building parameters for the proposed designs are indicated for each series. Parameters not described or defaulted in the series are those given in Appendix F.

5.1.2 Climate Zones

Eleven of the 16 climate zones and a sampling of city locations within climate zones are used in the tests (Table 5-1). These were chosen to represent distinctly different climate types.

Table 5-1: Climate Zones Tested

Weather Location	Climate Zone
Arcata, Eureka	1
Oakland	3
San Diego	7
Pomona, UCLA	9
Riverside	10
Red Bluff, Redding	11
Sacramento, Davis, Crockett, Fairfield, Roseville	12
Fresno, Visalia	13
China Lake	14
El Centro, Palm Springs	15
Mount Shasta, Tahoe City	16

5.1.3 Labeling Computer Runs

Each computer run used for the certification tests is given a precise designation to make it easier to keep track of the runs and to facilitate analysis. The following scheme is used:

A1 1 B 13

- 13 — Climate Zone for Test
- B — Prototype Building
- 1 — Test Number
- A1 — Test Series Category and Subcategory

The first three alphanumeric characters uniquely identify the test number. In this case A11 uniquely identifies the test case.

5.1.4 Comparison of Results

The vendors shall model the building characteristics described in Sections 5.2 and 5.3 as modifications to each of the base case buildings described in Section 5.1. The applicant shall provide results of runs for these building characteristics using consistent and equivalent input for the vendors ACM. The results of these runs shall be compared to the results of a custom budget for the standard building developed by the same program. The applicant shall calculate the following.

$$DTa = PTa - STa$$

and the Commission has already determined:

$$DTr = PTr - STr$$

Where:

Subscript “a” represents the results of the applicants ACM and subscript “r” represents the results of the reference program, and

PT is the total source proposed budget calculated for the building in kBtu/sf-yr,

ST is the total source standard budget in kBtu/sf-yr.

For all tests, DTa must be greater than 0.85×DTr - 1 kBtu/sf-yr when DTr ≥ 0 and DTa must be greater than (1.15×DTr - 1) when DTr < 0 to be accepted for compliance use. If any of the tests fail to meet these criteria then the ACM will not accepted for compliance use.

In addition, for individual tests of lighting and receptacle loads (or water heating) measures, the resultant lighting and receptacle source energy use of ACMs shall be within 2.0% of the resultant lighting source energy use of the reference program or the Commission shall not accept the applicants ACM.

The reference method does not allow for undersized systems to be simulated for compliance purposes. **ACMs must also model adequately sized HVAC systems** and compliance runs that indicate undersized equipment or equipment that cannot meet the heating or cooling loads for a significant fraction of the simulated run shall not be approved for compliance purposes. **For ACMs whose calculational engines report the hours that loads are not met or the hours outside of throttling range, reports must indicate that these hours are less than 10% of the hours of a year for each and every test in order for an ACM to qualify for approval.**

The results of these runs are summarized in tabular form as a part of the forms provided in Appendix A for the vendor to enter the data from their ACM test results. As previously described the vendor applicant may challenge the reference program results by providing alternative reference program runs and adequate documentation justifying different reference program results from those given in the Appendix A.

5.2 Required Capabilities Tests

An ACM must automatically perform a variety of functions including those described in Chapter 2. It must accept a specified range of inputs for the proposed design. It must then use these inputs to describe the proposed building on the required output forms. The proposed building inputs are also used to create a standard design building based on the proposed building and the energy budget generation rules used to incorporate the prescriptive requirements into the proposed design. Certain building descriptors remain the same for both the proposed and standard design but others will change in ways that depend upon the design characteristics, the climate zone, and the prescriptive and mandatory requirements of the standards. ACM assumptions for the DOE 2.1E computer program are given in brackets, e.g. [OH-A=0] or are described in information blocks of CAPITAL LETTERS. The energy budget generator must automatically define the standard design; determine the proper capacity of the HVAC equipment for the standard design; adjust the HVAC capacity of the standard design in accordance with the reference method; and automatically run the standard design to establish the energy budget. The ACM performs the energy budget run in sequence with the compliance run with no user intervention or input beyond that of the proposed design. The results are reported in Part 2 of the Performance Certificate of Compliance Form (PERF-2) when the proposed building design complies.

At a minimum the applicant will perform the tests listed in this Manual to assure the proper response of the ACM. These tests verify the implementation of the custom budget procedure, program accuracy and performance relative to the reference program, and acceptable use of calculation inputs.

These tests consist of a series of matched pairs of computer runs. Each matched pair consists of a proposed design (prototype variation) and the standard design equivalent to the proposed design. The standard design equivalent is the proposed design automatically reconfigured by the ACM according to the rules presented in Chapter 2.

The vendor/applicant must submit the completed forms from Appendix A, ACM Application Test Results Summary and backup documentation for the results of the tests described herein. For buildings that DO NOT COMPLY, the vendor must supply diagnositc output that indicates noncompliance and gives the energy budget information needed to evaluate the test criteria including the lighting and receptacle portions of the energy budgets for both proposed and standard design. For building designs that do comply the vendor/applicant must submit copies of Part 2 of the PERF-1 forms for all of the test cases.

Detailed information on the local and description of exterior partitions (walls, roof/ceiling, and floors) and the HVAC system and equipment information for each zone of each test is given in Appendix F.

For some of the tests specific occupancy mixes are used in these tests and are designated by the primary occupancy. The distribution of occupancy areas of these mixes are given in the table below. These mixes were selected to result in lighting energy densities nearly the same as those for the occupancy assumptions for spaces/areas without lighting plans.

Primary Occupancy	**Suboccupancy Percentages**			
Mix Type	*Primary*	*Office*	*Corridor/Support*	*Storage*
Office	87.5%	87.5%	12.5%	
Retail	85.0%	3.5%	3.5%	8.0%
Clinic	85.0%		15.0%	
Storage	72.0%	18.0%	10.0%	
Grocery	82.0%	4.0%	6.0%	8.0%
				Lobby
Theater	70.0%	16.0%	4.0%	10.0%
	Dining Area	*Kitchen*		*Storage*
Restaurant	75.0%	15.0%	5.0%	5.0%
	Other			
Other	100.0% (Receptacle Load at 1.0 W/sf)			

5.2.1 Partial Compliance Tests - A1 Series (3 tests)

The partial compliance tests use the single zone version of the A building prototype with the same features used (except as noted) in test C11A10 in Section 5.2.4.1.

Test A11A09: Building Prototype A - Climate Zone 09 - Pomona

Partial Compliance - Envelope Only.

Test A12A09: Building Prototype A - Climate Zone 09 - Pomona

Partial Compliance - Lighting Only - Envelope is already existing as input. Proposed lighting plans specify lighting watts per square foot:

Subzone Space Occupancy	Percentage of Area	Proposed Lighting
Grocery Sales Area	82%	1.50
Grocery Storage (Commercial Storage)	8%	0.80
Support/Corridors	6%	0.80
Office	4%	1.80

Test A13A09: Building Prototype A - Climate Zone 09 - Pomona

Partial Compliance - Envelope and Mechanical Only. No lighting plans submitted for grocery occupancy.

5.2.2 Exterior Opaque Envelope Tests

The exterior wall tests help to evaluate whether the applicant ACM inserts the correct wall assemblies into the standard design as a function of the proposed design including wall frame type, heat capacity, occupancy type and climate zone. These tests use the eight (8) zone B building prototype without interior zones to increase the tests sensitivities to envelope energy impacts.

The default characteristics for these tests are:

- Prototype Building B (geometry, zones, and walls)
- Office Occupancy With No Lighting Plans
- 3.5 inch concrete slab-on-grade floor [U-F CONS=SLABC]
- Wood-framed roof - Framing Materials and Layers Type RF1C - Wood Framing fraction is 10%.
- All wood-framed vertical walls [W2A walls] have a 15% framing fraction, i.e. 85% of the wall is insulation.
- Package Single Zone System (Gas Furnace) without economizers or Package Variable Air Volume System with Economizer Cycle [Standard DOE 2.1E Economizer] and 75 degree Fahrenheit economizer limit temperature - [ECONO-LIMIT-T = 75.0]
- Window Wall Ratio = .10 for opaque envelope tests
  [WWR = 0.10]
- Glazing performance equal to prescriptive requirements
- Lighting wattage at 1.50 watts per square foot

5.2.2.1 Opaque Exterior Envelope - A2 Series (7 tests)

These tests use the default B Prototype building geometry and zone configuration. Run tests using wall assemblies W2A, W1A, W4A, and W3A for North, East, South and West walls respectively and Roof Assembly RF1C-NR. The framing percentage used for wood frame walls, e.g. Wall Type W2A, is 15% [i.e. 15% of the wall is W2A-FRM and 85% is W2A-INS] and the framing percentage used for wood frame roof/ceilings is 10% [e.g. 90% is RF1C-NR and 10% is RF1C-NRF]. For Tests A21 and A25 use package single zone [PSZ] HVAC equipment in climate zones 13 and 03 respectively. For tests A22, A23, A24 use a package variable air volume [PVAV] system in climate zones 13, 06, and 16 respectively. Test again (A26 and A27) using wall assemblies W2D, W1D, W4D, and W3B for North, East, South and West walls respectively and roof assembly RF1D-NR. For test A26 use a package single zone [PSZ] HVAC system in climate zone 13 and for test A27 use a package variable air volume [PVAV] system in climate zone 16.

Table 5-2: A2 Test Series Summary

Test Run	HVAC System	North Wall	East Wall	South Wall	West Wall	Roof
A21B13	PSZ	W2A	W1A	W4A	W3A	RF1C-NR
A22B13	PVAV	W2A	W1A	W4A	W3A	RF1C-NR
A23B06	PVAV	W2A	W1A	W4A	W3A	RF1C-NR
A24B16	PVAV	W2A	W1A	W4A	W3A	RF1C-NR
A25B03	PSZ	W2A	W1A	W4A	W3A	RF1C-NR
A26B13	PSZ	W2D	W1D	W4D	W3B	RF1D-NR
A27B16	PVAV	W2D	W1D	W4D	W3B	RF1D-NR

5.2.3 Envelope Glazing Tests

The envelope glazing tests are to check whether the ACM applicant inserts the correct vertical glazing types and areas into the standard design as a function of proposed design glazing orientation, area, occupancy and display perimeter length. As for the opaque envelope tests, the eight (8) zone B prototype building is used to enhance the sensitivity of the tests for envelope measures.

The prototypes for these tests have the following characteristics:

- Prototype Building B, and if not otherwise specified.
- Retail Store occupancy with no lighting plans, hence lighting is at 1.70 watts per square foot.
- Same wall and roof assemblies as for Section 5.2.2 base case file, namely, wall assemblies W2A, W1A, W4A, and W3A for North, East, South and West walls respectively and Roof Assembly RF1C-NR.
- Window Wall Ratio Default of 0.35 [WWR=0.35]
- 3.5 inch concrete slab-on-grade floor
- Package Variable Air Volume System with Economizer Cycle and 75 degree Fahrenheit economizer limit temperature - [ECONO-LIMIT-T = 75.0]

Tests B31 and B32 use Prototype Building D to test skylight and display perimeter custom budget generation and to simultaneously test ACM overhang modeling.

The prototype has the following characteristics:

- Prototype Building D
- Retail (85%) and Storage (15%) Occupancies hence lighting at 2.00 watts per square foot for the retail and 0.6 watts per square foot for the commercial storage portion at the back.
- 3.5 inch concrete slab-on-grade floor [U-F CONS=SLABC]
- At zero building azimuth the long axis of the building zones run due east to west.
- All "exterior" vertical walls of the two unconditioned zones are 2x4 steel-framed walls with framing 16" o.c. and R-11 insulation between framing members. These walls have stucco and plywood on the exterior and sheetrock on the interior [CONS = METALOC].
- The vertical walls between the conditioned zone and the two unconditioned zones are 2x4 steel-framed walls with framing 16" o.c. and R-11 insulation between framing members. These walls have sheetrock on both sides [CONS = INTWALL].
- The southern exterior vertical wall of the conditioned zone is a steel-framed W1A [METAL-WALL] wall and the northern wall is a massive [HEAVY-WALL] W4A wall.
- Wood framed roof - Framing Materials and Layers Type RF1C
- For the B31 and B32 test runs the Window Wall Ratio is .50 for both exterior walls of the conditioned space [WWR = 0.50]. These windows start on the ground.
- The B31 and B32 test runs both include double pane skylights.
- Clear single pane glass for all glass with 9% aluminum framing with thermal break, SHGC=0.82, G-C=1.62, and VT=0.88.
- Package single zone system with economizer cycle and compressor lockout (non-integrated economizer [ECONO-LIMIT-T = 75]

5.2.3.1 Vary Window Wall Ratio - B1 Series (5 tests)

These tests exercise the automatic determination of standard design window wall ratios. These tests are performed using Building B. The first three (B11, B12, and B13) are modeled in climate zone 13 and the last two in climate zones 06 and 16 respectively. Wall types W1A, W2A, W3A, and W4A are used as in test series A2. All glazing performance characteristics shall be consistent with the prescriptive standards and no overhangs or side fins will be simulated. The glass will be a continuous band of uniform height around the entire building. Window wall ratios are set at 0.35, 0.40, and 0.45 respectively. The building with a WWR of 0.45 are also simulated in climate zones 06 and 16 for tests B14 and B15.

When the Window-Wall Ratio is tested at 0.45 [WWR = 0.45] the proposed building is tested with clear low emissivity dual pane glass with 9% aluminum framing with thermal break, SHGC=0.58, G-C=0.68, and VT=0.72.

Tests: B11B13, B12B13, B13B13, B14B06, and B15B16.

5.2.3.2 Vary Glazing Types With An Overhang - B2 Series (4 tests)

These tests examine the ACM's sensitivity to the energy tradeoffs between extra glazing and overhangs. The first three tests are performed using Building B in climate zone 12 with the building rotated 15 degrees to the east in azimuth. The last test is performed in climate zone 03. A retail occupancy is modeled. Overhangs, six feet deep [OH-D=6], 60 feet wide [OH-W=60], and 0.1 foot above the top of the glass [OH-B=0.1] and no extension [OH-A=0] are modeled on the windows. However, no side fins or other building shading will be simulated. The glass will consist of two continuous bands with their bottom edges 2.5 feet from the floor and a height equivalent to a window wall ratio of 0.42 [WWR =.42] around the entire building. The first three runs will use the three different glass types indicated below for windows on all walls including the north wall. Clear low emissive dual pane glass [9% aluminum framing with thermal break, SHGC=0.58, G-C=0.68, and VT=0.72] will also be simulated in climate zone 03.

Tests: B21B12, B22B12, B23B12, and B24B03

5.2.3.3 Display Perimeter & Skylight Tests - B3 Series (2 tests)

These tests examine the ACM's sensitivity to variations in both display perimeter and skylights. These tests are performed using Prototype D in climate zone 12. A 4 foot deep, [OH-D=4], 20 foot wide [OH-W=20] overhang, 2 feet above the window [OH-B=2] with no extension [OH-A=0] will be modeled. The building will be rotated 165 degrees clockwise or to the east [BUILDING LOCATION AZ = 165] facing the glazed wall 15 degrees to the east of due South. No side fins or other building shading will be simulated. The glass will be a 6 foot high panel of clear single pane glass [9% aluminum framing with thermal break, SHGC=0.82, G-C=1.62, and VT=0.88] on both exterior end walls with its bottom edge at floor height. The display perimeter option will be selected with a display perimeter of 40 feet for the D prototype building. [WWR = 0.500 for six foot high glass.] Test B31 will have 5% of the roof area in double pane transparent skylights [9% aluminum framing with thermal break, SHGC=0.44, G-C=1.02, and VT=0.80] and test B32 will have 10% of the roof area in double pane translucent skylights [9% aluminum framing with thermal break, SHGC=0.70, G-C=1.02, and VT=0.61].

Tests: B31D12 and B32D12

5.2.4 Occupancy Tests

The occupancy tests check to see if the ACM applicant inserts the correct schedules, envelope performance requirements, fixed values for internal loads and ventilation rates as a function of the occupancy type. Window wall ratio has been lowered to 0.20 for building prototype A and 0.30 in prototype B to increase the sensitivity of the tests to the choice of occupancy.
The prototypes for these test all have the following characteristics:

- Prototype Building A
- Specified Occupancy Mixes except lighting at 0.05 watts per square foot higher than allowed by Table 2-2 with lighting plans submitted.
- Wood framed roof - Framing Materials and Layers Type RF1B
- Suspended Wood Floor - Framing Materials and Layers Similar to Nonresidential Manual, Floor Type FX.0.2X6.16 with 10% 2x6 framing and no insulation. Note that the interior air film is 0.61 and thus the overall ~~U-value~~U-factor is 0.260.
- Package Single Zone System with economizer cycle and 75 degree Fahrenheit limit temperature

[ECONO-LIMIT-T = 75.0]
- Window Wall Ratio = .20
- Glazing meets prescriptive standards for CZ13

Tests will also be run for a mixed office, retail, restaurant, and heated-only warehouse occupancies for Prototype Building B and a second mixed occupancy test will be done using prototype C as a "prototype" high-rise hotel.

- Prototype Buildings B (ten zone version)
- Modeled occupancy mixes except lighting at 0.02 watts per square foot lower than allowed by Table 2-2 with lighting plans submitted.
- 3.5 inch concrete slab-on-grade floor [U-F CONS=SLABC]
- Wood framed roof - Framing Materials and Layers Type RF1C
- Two (Interior Zones and Perimeter Zones) Packaged Variable Air Volume Systems with Electric Reheat and Economizer Cycle and 75 degree Fahrenheit economizer limit temperature for Prototype B. [ECONO-LIMIT-T = 75.0]
- Window Wall Ratio = .30 [WWR = 0.35]
- Glazing performance equal to prescriptive requirements

Prototype building C is described in detail below by the reference program input files. The mixed-occupancy high-rise hotel has a hotel lobby, office, and three retail zones on the first floor; hotel guest rooms on the middle floors; and three hotel function area zones, a kitchen, and dining zone on the top floor. In addition to the primary occupancy, each perimeter HVAC zone has 12% of its area as corridor, restroom, and support occupancy. The interior or core HVAC zones have 20% of their area as corridor, restroom, and support occupancy to account for elevators and electrical and mechanical chases.

- Prototype Building C
- Lighting is set to the prescriptive requirement for each occupancy task/area per Table 2-2.
- Concrete spandrel panel walls [MAT = (CC22,W1B-R13,GP02)]
- Raised concrete floor
  for Floor1 [MAT = (CEL-2.5,CC03,CP01)]
  for Floor2 [MAT = (CEL-2.5,CC05,CP01)]
  where
  [CEL-2.5 = MAT TH=.2083 COND=.0333 DENS=5 S-H=.32]
- Plywood deck, rigid insulation w/built-up roof Exterior roof [MAT = (BR01,ISO-3.0,PW04) where
  ISO-3.0=MAT TH=.25 COND=.01417 DENS=1.5 S-H=.38]
  Interior Roof [MAT = (CC04,CP01)
- Variable Air Volume System with Hot Water Reheat and Economizer Cycle and 75 degree Fahrenheit economizer limit temperature serving non-hotel room occupancies
  [ECONO-LIMIT-T = 75.0]
- Four pipe fan coil system serving all hotel rooms
- Window Wall Ratio = .35 [WWR = 0.35]
- Glazing performance equal to prescriptive requirements for climate zone 13 Double pane clear windows [9% aluminum framing with thermal break, SHGC=0.77, G-C=0.838, and VT=0.80] are used for north-facing glazing and non-north-facing guestroom glazing. Double pane bronze windows [9% aluminum framing with thermal break, SHGC=0.50, G-C=0.838, and VT=0.47] are used for non-north-facing glazing for all other occupancies.

5.2.4.1 Single Occupancy Tests - C1 Series (5 tests)

These tests will be performed using the Building A in climate zone 10 for the 5 occupancy mixes listed below. Suboccupancy assumptions are given in Table 2-2 of this manual:

- Grocery 82% Grocery Sales 8% Storage 6% Support 4% Office

- Restaurant 65% Dining Area 30% Kitchen 5% Support
- Theater 70% Theater(Perf) 20% Lobby 5% Support 5% Office
- Clinic 50% Medical-Clinic 25% Office 25% Support
- All "Other" 100% Other

Tests: C11A10, C12A10, C13A10, C14A10, and C15A10

5.2.4.2 Mixed Occupancy Tests - C2 Series (2 tests)

a) This test will be performed using the ten zone version of Prototype Building B in climate zone 10 with the first story north and south zones retail, first story east and west zones heated-only warehouses and the first floor interior zone and all second story zones are office occupancies.

- Packaged Single Zone [PSZ] Gas/Electric HVAC systems are modeled in the heated-only warehouse zones in lieu of the Packaged variable Air Volume [PVAV] system.

b) This test will be performed using the Prototype Building C in climate zone 16 with the first story having retail occupancies in all zones except for the west zone which is a hotel lobby and the south zone which is an office, four middle stories of hotel guest rooms with five zones per floor, and a top floor with hotel function zones for the north, east, and west zones, a kitchen for the interior zone and dining occupancy in the south zone.

Tests: C21B10 and C22C16

5.2.5 Lighting Tests - D1 Series (4 tests)

The lighting tests check whether the ACM applicant inserts the correct lighting levels, per zone, into the standard design.

The prototype has the following characteristics:

- Prototype Building D
- Retail Area Occupancy with lighting plans
- 3.5 inch concrete slab-on-grade floor [U-F CONS=SLABC]
- Wood framed roof - Framing Materials and Layers Type RF1C
- Window Wall Ratio of .30 [WWR = 0.30]
- Clear single pane glass for all glass with 9% aluminum framing with thermal break, SHGC=0.82, G-C=1.62, and VT=0.88.
- Package single zone system with economizer cycle and compressor lockout (non-integrated economizer [ECONO-LIMIT-T = 75]

These tests are performed using Building D in climate zones 12 (Sacramento) and 07 (San Diego) with two different lighting levels, 1.50 watts per square foot and 1.70 watts per square foot.

Tests: D11D12, D12D12, D13D07, and D14D07

5.2.6 Ventilation Tests - E1 Series (6 tests)

The ventilation tests check whether the ACM applicant inserts the correct tailored ventilation rates, per zone, into the standard design. These tests are performed using Building D in climate zone 16 with three different combinations of tailored ventilation rates. Repeat these tests in climate zone 14.

The prototype has the following characteristics:

- One zone Industrial and Commercial Storage occupancy with lighting plans showing 0.8 watts per square foot of lighting
- 3.5 inch slab on grade floor
- Wood framed roof - Framing Materials and Layers [Roof Type RF1C]
- Window Wall Ratio of 0.10
- Clear double pane glazing on exterior walls with 9% aluminum framing with thermal break, SHGC=0.77, G-C=0.838, and VT=0.80.
- Package Single Zone system with no economizer

First, standard outside air per person [OA-CFM/PER] rates are used based on occupancy assumptions in Table 2-1 or 2-2. Next outside air per person [OA-CFM/PER] rates are increased by a factor of 1.5 as a tailored ventilation entry. Finally, outside air per person [OA-CFM/PER] rates are increased by a factor of three as a tailored ventilation entry.

Tests: E11D16, E12D16, E13D16, E14D14, E15D14, and E16D14

5.2.7 Process Loads Tests - E2 Series (6 tests)

The process loads tests check the energy budget effects of zonal process (tailored) equipment levels and microclimate sizing in a proposed building design. These tests are performed using Prototype Building B with conditioned interior zones in climate zone 16 (Tahoe City) with three different extra process loads of 0.50, 1.00, and 2.00 watts per square foot of process heat scheduled as equipment. Repeat these tests in climate zone 12 (Davis).

The prototype has the following characteristics:

- Prototype Building B including 30'x30' interior zones
- Office occupancy
- 3.5 inch concrete slab-on-grade floor [U-F CONS=SLABC]
- Wood framed roof - Framing Materials and Layers Type RF1C
- Package Variable Air Volume System with Integrated Economizer Cycle and 75 degree Fahrenheit economizer limit temperature - [ECONO-LIMIT-T = 75.0]
- Window Wall Ratio = .30 [WWR = 0.30]
- Single pane reflective glass with solar heat gain coefficient of 0.40 [9% aluminum framing with thermal break, G-C=1.62, and VT=0.22] everywhere.
- Lighting wattage at 1.20 watts per square foot

Tests: E21B16, E22B16, E23B16, E24B12, E25B12, and E26B12

5.2.8 HVAC System Tests - F1 Series (5 tests)

The HVAC system tests check the ACM's sensitivity to variations in HVAC system type and the selection of comparative systems for the standard design as a function of specific city location within climate zone, occupancy, square footage and proposed HVAC system type. Test F15A16 is a heated-only warehouse with electric resistance heating. The systems to be used for establishing custom budgets, are described in Chapter 2.

Tests 1 and 2 (F11A07 & F12A13):

- Prototype Building A
- Medical office/clinic occupancy
- Window wall ratio of 40% [WWR = 0.40]
- Heat Pump System
- F11A07 modeled in Climate Zone 07 (San Diego)
- F12A13 modeled in Climate Zone 13 (Visalia)

Tests 3 and 4 (F13B12 & F14B12):

- Prototype Building B - 8 zone version
- Retail occupancy
- Window wall ratio of 35% [WWR = 0.35]
- PVAV with electric reheat and no hot water coils or boilers
- F13B12 modeled in Climate Zone 12 (Sacramento)
- F14B12 modeled in Climate Zone 12 (Crockett)

Test 5: (F15A01)

- Prototype Building A
- Heated Only Warehouse occupancy - gas-fired unit heater
- Modeled with clear, double pane, low emissivity glass, 9% aluminum framing with thermal break, SHGC=0.58, G-C=0.68, and VT=0.72.
- Window wall ratio of 35% [WWR = 0.35]
- Electric Resistance Heating - No cooling installed
- F15A01 modeled in Climate Zone 01 (Eureka)

Table 5-3: F1 Test Series Summary

Test Run	HVAC System	Location	WWR	Occupancy
F11A07	Heat Pump	San Diego	0.40	Medical
F12A13	Heat Pump	Visalia	0.40	Medical
F13B12	PVAV with electric reheat	Sacramento	0.35	Retail
F14B12	PVAV with electric reheat	Crockett	0.35	Retail
F15A01	Electric resis. heating only	Eureka	0.35	Warehouse

5.2.9 System Sizing Tests - G1 Series (6 tests)

The system sizing tests check whether the ACM applicant calculates and simulates the correct capacities for both the proposed and standard design systems as a function of the input HVAC system capacities.

These tests are divided among undersized systems, oversized systems and combinations of oversized and undersized system components (eg. oversized cooling and undersized zone reheating capacities). For the purposes of these tests OVERSIZED means 100 percent over estimated load and UNDERSIZED means 50 percent of the estimated load.

The system sizing tests will be performed in climate zones 3, 11, and 16. Tests 1,2,3 & 4 will be performed using building prototype A in climate zone 11 and tests 5 and 6 using the ten zone building prototype B in climate zones 03 and 16 respectively. Tests 5 and 6 will be performed using the ten HVAC zone version of Prototype Building B. Systems will be both undersized by 50% (tests 2 & 4) and oversized by 100% (tests 1 & 3.) Tests 5 and 6 have both undersized and oversized systems and components (boilers) serving different zones.

Tests 1 and 2 (G11A11 & G12A11):

- Prototype Building A
- Medical office / clinic occupancy
- Window wall ratio of 40% [WWR = 0.40]
- Oversized (G11) and Undersized (G12) PSZ - Package Gas / Electric - System (Gas Furnace and DX Cooling)
- Climate Zone 11 (Red Bluff).
- No Economizer

Tests 3 and 4 (G13A11 & G14A11):

- Prototype Building A
- Medical office / clinic occupancy
- Window wall ratio of 40% [WWR = 0.40]
- Oversized (G13) and Undersized (G14) Heat Pump System
- Climate Zone 11 (Red Bluff).
- No Economizer

Tests 5 and 6 (G15B03 & G16B16):

- Prototype Building B - 10 zone version
- Office occupancy
- Window wall ratio of 35% [WWR = 0.35]
- Integrated Economizers with 75 degree dry-bulb lockout
- For G15 - Oversized boiler, Undersized PVAV with electric reheat for exterior zones, Oversized PVAV for interior zones
- For G15 Climate Zone 03 (San Francisco)
- For G16 - Undersized boiler, Oversized PVAV with electric reheat for exterior zones, Undersized PVAV for interior zones
- For G16 - Climate Zone 16 (Tahoe City)

5.2.10 HVAC Distribution Efficiency Tests

Description: ACM duct efficiency calculations shall match the values shown in Appendix H

5.3 Optional Capabilities Tests

ACMs may also model other optional capabilities or have optional compliance capabilities for additions and alterations. In the last edition of this manual tests for optional capabilities were left to be proposed by the vendor desiring to incorporate particular optional capabilities into their ACM. These tests were approved in conjunction with the approval of the ACM by the Commission. Most of the tests specified for optional calculational capabilities herein were originally proposed by the vendor of COMPLY24, Gabel-Dodd Associates. The tests for optional capabilities are based on the tests proposed by Gabel-Dodd Associates.

The first series of optional tests are special tests to test certain compliance options - partial compliance and modeling of an addition and an existing building with alterations. In addition to the test criteria for the energy results, compliance forms must conform to the requirements for these special compliance options for the ACM to be approved.

The main body of optional capabilities tests deal with additional HVAC systems and plant capabilities that can be modeled by the DOE 2.1 (especially DOE 2.1E) computer program. These tests and the reference comparison method for these tests conform to the features and rules specified in Chapters 2 and 3 of this manual unless specifically noted otherwise.

5.3.1 OC Test Series - Compliance Options

Test OC1A09: Building Prototype A - Climate Zone 09 - UCLA

Combined compliance for an altered existing building with a noncomplying addition. Occupancy is an existing restaurant in a prototype A building. A new solarium is submitted as an addition to the restaurant. The solarium addition is 20 feet deep by 30 feet wide and is 12 feet high adjacent to the wall of the existing building descends to 8 feet at the outer glass wall of the addition. The addition has been added onto the eastern 30 foot wide end of the A prototype building and that eastern wall and its glazing is removed with the construction of the addition. The vertical walls of the addition have 2.5 foot knee walls with the rest of the walls consisting entirely of high performance glass:

- knee walls - insulated spandrel panels

  SPANDREL-R10 Assembly

- sloped roof - insulated spandrel panels

  SPANDREL-R15 Assembly

- vertical glass walls

  GR4SC26 Assembly [dual pane glass, 9% aluminum framing with thermal break, SHGC=0.26, G-C=0.2629, and VT=0.10]

- sloped glazing in roof

  GR4SC18 Assembly [dual pane glass, 9% aluminum framing with thermal break, SHGC=0.18, G-C=0.2629, and VT=0.08]

There is NO roof overhang extending beyond the addition's vertical walls. The original restaurant lighting of 2.00 watts per square foot has been altered to 1.60 watts per square foot to compensate for the extra glass in the solarium addition. The 30 foot wide eastern wall is removed to open the existing building to the solarium addition. The remainder of the A building prototype has exactly the same characteristics, including non-lighting occupancy assumptions, used in the proposed building for test C12A10 and is not altered for compliance. To be approved for the capability of partial compliance all ACM output and reporting requirements MUST be met.

5.3.2 O1 Test Series - Fan Powered VAV Boxes

These tests use the ten zone version of the B building prototype with the same features used (except as noted) in test B11B13. All rules applicable to System #4 (Built-up VAV) described in Section 2.5-- Required Systems and Plant Capabilities--also apply to Fan-powered VAV boxes or Power Induction Units [PIU]. In particular, the rules used to determine a standard HVAC system are the rules for System #4.

Test O11B13: Building Prototype B - Climate Zone 02 - Napa

Central VAV with hot water reheat. Each perimeter zone has a 600 cfm Parallel Fan Powered VAV Box. The reference method does not use the [ZONE-FAN-CFM] input, but does set [TERMINAL-TYPE = PARALLEL-PIU], [ZONE-FAN-KW is set greater than or equal to 0.00033], the [ZONE-FAN-T-SCH] is set 1 ^{o}F above heating setpoints, [MIN-CFM-RATIO = 0.3], and ACM input for the [ZONE-FAN-RATIO] or its equivalent is restricted to the range of 0.4 to 1.00. The ACM must automatically determine or the ACM user must enter an [INDUCED-AIR-ZONE] which is different than the zone served. For the reference program and method, the [INDUCED-AIR-ZONE] must be the U-name (user name) of another zone.

Test O12B13: Building Prototype B - Climate Zone 02 - Napa

Central VAV with hot water reheat. Each perimeter zone has a 600 cfm Series Fan Powered VAV Box. The reference method does not use the [ZONE-FAN-CFM] input, but does set [TERMINAL-TYPE = SERIES-PIU], [ZONE-FAN-KW is set greater than or equal to 0.00033], the [ZONE-FAN-T-SCH] is set 1 ^{O}F above heating setpoints, [MIN-CFM-RATIO = 0.3], and ACM input for the [ZONE-FAN-RATIO] or its equivalent is restricted to the range of 0.4 to 1.00. The ACM must automatically determine or the ACM user must enter an [INDUCED-AIR-ZONE] which is different than the zone served. For the reference program and method, the [INDUCED-AIR-ZONE] must be the U-name (user name) of another zone.

5.3.3 O2 Test Series - Supply/Return Fan Options

This series tests various fan options for central VAV system fans. These tests use the ten zone version of the B building prototype with the same features used (except as noted) in test B11B13. All runs have a central VAV HAVC System with a gas-fired boiler to supply hot water reheat.

Test O21B13: Building Prototype B - Climate Zone 13 - Fresno

The supply fan uses an Air Foil Fan with Inlet Vane Control to control fan volume. The fan part-load curve is taken from the Commission's *DOE-2 Compliance Supplement*.

Test O22B13: Building Prototype B - Climate Zone 13 - Fresno

The supply fan uses an Air Foil Fan with Discharge Damper Control to control fan volume. The fan part-load curve is taken from the Commission's *DOE-2 Compliance Supplement*.

Test O23B13: Building Prototype B - Climate Zone 13 - Fresno

The supply fan uses an Forward Curve Fan with Inlet Vane Control to control fan volume. The fan part-load curve is taken from the Commission's *DOE-2 Compliance Supplement*.

Test O24B13: Building Prototype B - Climate Zone 13 - Fresno

The supply fan uses a Vane Axial Fan Control to control fan volume. The fan part-load curve is taken from the Commission's *DOE-2 Compliance Supplement*.

5.3.4 O3 Test Series - Special Economizer Options

This series tests various economizer options. These tests use the A building prototype with the same features used (except as noted) in test C11A10. All runs have a Packaged Single Zone HVAC System with a gas-fired furnace and electric DX cooling. The building uses a grocery occupancy mix contained within a single (one thermostat) HVAC zone.

Proposed plans specify the suboccupancies within the single HVAC zone with lighting watts per square foot:

Subzone Space Occupancy	Percentage of Area	Proposed Lighting
Grocery Sales Area	82%	1.50
Grocery Storage (Commercial Storage)	8%	0.80
Support/Corridors	6%	0.80
Office	4%	1.80

Test O31A12: Building Prototype A - Climate Zone 12 - Fairfield

The HVAC system is equipped a fixed enthalpy integrated economizer control for more efficient cooling. The DOE 2.1E economizer function is used with [OA-CONTROL = TEMP], [ECONO-LIMIT-T = 75], [ENTHALPY-LIMIT = 25.0 Btu/lb], and [ECONO-LOCKOUT = YES].

Test O32A12: Building Prototype A - Climate Zone 12 - Fairfield

The HVAC system is equipped a fixed enthalpy non-integrated economizer control for more efficient cooling. The DOE 2.1E economizer function is used with [ENTHALPY-LIMIT = 25.0 Btu/lb] and [ECONO-LOCKOUT = NO].

Test O33A12: Building Prototype A - Climate Zone 12 - Fairfield

The HVAC system is equipped a differential enthalpy integrated economizer control for more efficient cooling. The DOE 2.1E economizer function is used with [OA-CONTROL = ENTHALPY].

5.3.5 O4 Test Series - Special HVAC Control Option

Test O41B13: Building Prototype B - Climate Zone 13 - Fresno

This test exercises a Warmest Zone Cooling Coil Control option. This test uses the ten (10) zone version of building prototype B with the same features used (except as noted) in test B11B13.

5.3.6 O6 Test Series - Additional Chiller Options

This series tests various chiller options. These tests use the ten (10) zone B building prototype with the same features used (except as noted) in test F14B13. All runs have a central HVAC System with one of the new chiller options and a gas-fired boiler and use hot water reheat.

Test O61B12: Building Prototype B - Climate Zone 12 - Roseville

The chiller for this test is a Single Stage Absorption Chiller modeled with an EIR = 0.004 and an HIR = 1.6.

Test O62B12: Building Prototype B - Climate Zone 12 - Roseville

The chiller for this test is a Two Stage Absorption Chiller modeled with an EIR = 0.004 and an HIR = 1.0.

Test O63B12: Building Prototype B - Climate Zone 12 - Roseville

The chiller for this test is a Gas-Fired Absorption Chiller modeled with an EIR = 0.0114 and an HIR = 1.0.

Test O64B12: Building Prototype B - Climate Zone 12 - Roseville

The chiller for this test is a Variable Speed Drive (VSD) Chiller modeled with an EIR = 0.2275.

Test O65B12: Building Prototype B - Climate Zone 12 - Roseville

The chiller for this test is a Screw Chiller modeled with an EIR = 0.2275.

Test O66B12: Building Prototype B - Climate Zone 12 - Fairfield

The chiller for this test is also a Screw Chiller modeled with an EIR = 0.2275 in a different city in Climate Zone 12.

5.3.7 O7 Test Series - Additional HVAC System Options

This series tests various additional HVAC system options. These tests use the ten (10) zone B building prototype with the same features used (except as noted) in test F13B12. All runs have a central HVAC System with the same chiller as that used in test F13B12 and (where needed) a gas-fired boiler for hot water reheat.

Test O71B12: Building Prototype B - Climate Zone 12 - Sacramento

Individual Hydronic Heat Pumps (< 75K Btuh) are modeled for each zone. The heat pumps all have EER = 11.0 and COP = 3.8.

5.3.8 O8 Test Series - Optional Shading Devices

This test series tests the effects of optional shading devices, in particular sidefins. In this series sidefins are tested in two hot climate zones at both ends of the state to maximize differences in latitude and thus solar angles. The building is the same as that used in Test C11A10 except as noted below.
The occupancies and lighting are the same as that specified for **Test OC2A09** and the **O3 Test Series**.

Test O81A11: Building Prototype A - Climate Zone 11 - Red Bluff

The glazing is the same as in Test C11A10 except that there are 2 foot deep sidefins every 5 feet that are the same height as the windows.

Test O82A15: Building Prototype A - Climate Zone 15 - Palm Springs

This test is the same as O81A11 except that the test is modeled in Climate Zone 15 - Palm Springs.

5.3.9 O9 Test Series - Evaporative Cooling Options

This test series tests direct, indirect, and direct/indirect evaporative cooling systems. Evaporative cooling is used both alone or as a precooling system. The building is the same as that used in Test C11A10 except as noted below. The occupancy type is the Grocery with 12% storage space; and lighting (with lighting plans) is set at 1.65 watts per square foot for all spaces modeled.

Standard Design Assumptions . The standard HVAC system for evaporative cooling is a DOE 2.1E gas/electric Packaged Single Zone unit [DOE 2.1E PSZ] with a fan power index 0.196 watts per cfm less than the proposed system which has additional fan capacity to move high air volumes required for evaporative cooling. The DOE 2.1E reference program characteristics for the standard system include [SUPPLY-DELTA-T = 1.815] and [SUPPLY-KW = 0.000587].

Proposed Design Assumptions. The proposed HVAC system for these O9 series tests will include the evaporative cooling system plus a backup DOE 2.1E Packaged Single Zone [PSZ] with [SUPPLY-DELTA-T = 2.42] to account for additional heating of the air stream by additional and/or larger fans, [SUPPLY-KW = 0.000783] to account for the evaporative cooling fan. **ACMs may allow user entry of supplementary fan and pump power but they must have a minimum supplementary power use (similar to the fan power index) of 0.5 watts per cfm to account for supplementary fans and pumps [EVAP-CL-KW not less than 0.0005 (DOE 2.1 Default)].** The entry for [EVAP-CL-KW] for DOE 2.1E is given:

$$[EVAP - CL - KW] = 0.746 \times \frac{(EF_{sp} + EP_{sp})}{0.85}$$

where

EF_{sp}	is the nameplate horsepower of the evaporative supplementary fan(s)
EP_{sp}	is the nameplate horsepower of the evaporative supplementary pump(s)
0.85	is a power factor to convert nameplate horsepower to brakehorsepower

For the proposed design, an ACM must limit direct and indirect evaporative cooling effectiveness to the DOE 2.1E defaults as a maximum entry.

Test O91A13: Building Prototype A - Climate Zone 13 - Fresno

A Packaged Single Zone system is modeled with supplemental Indirect Evaporative Cooling. This test is used to verify the proper upsizing of an undersized cooling system, as well as to ensure that the evaporative cooling is not upsized. This test is also used to verify the correct accounting of supplemental energy associated with the evaporative cooling process, and the implementation of the indirect cooling algorithms.

Test O92A11: Building Prototype A - Climate Zone 11 - Redding

A Standalone Indirect/Direct Evaporative Cooler is modeled with no supplemental air conditioning proposed. This test is used to verify the correct selection of the standard HVAC system and the ability of the ACM to create the proper cooling system which functions with the evaporative cooling system as a supplement to mechanical cooling. This test is also used to verify the correct implementation of the Indirect/Direct evaporative cooling algorithms.

Test O93A12: Building Prototype A - Climate Zone 12 - Roseville

A Standalone Indirect/Direct Evaporative Cooler is modeled with no supplemental air conditioning proposed. This test is the same as Test 092A11 except modeled in a different city with a milder cooling climate where the evaporative cooler alone may be sufficient. This test is used to verify the correct selection of the standard HVAC system and the ability of the ACM to determine the need for the proper cooling system which functions with the evaporative cooling system as a supplement to mechanical cooling and create it if needed.

Test O94A13: Building Prototype A - Climate Zone 13 - Fresno

A Standalone Indirect/Direct Evaporative Cooler is modeled with no supplemental air conditioning proposed. This test is the same as Test 092A11 except modeled in a different city with a milder cooling climate where the evaporative cooler alone may be sufficient. This test is used to verify the correct selection of the standard HVAC system and the ability of the ACM to determine the need for the proper cooling system which functions with the evaporative cooling system as a supplement to mechanical cooling and create it if needed.

CHAPTER 6. Vendor Requirements

Each ACM vendor must meet all of the following requirements as part of the ACM approval process and as part of an ongoing commitment to users of their particular program.

6.1 Availability to Commission

All ACM vendors are required to submit at least one fully working program version of the ACM to the California Energy Commission. An updated copy or access to the approved version of the ACM must be kept by the Commission to maintain approval for compliance use of the ACM.

The Commission agrees not to duplicate the ACM except for the purpose of analyzing it, for verifying building compliance with the ACM, or to verify that only approved versions of the ACM are used for compliance.

6.2 Building Department Support

ACM vendors must provide a copy of the ACM Compliance Supplement (or ACM Compliance User's Manual) to all local building enforcement agencies who request one in writing.

6.3 User Support

ACM vendors must offer support to their users with regard to the use of the ACM for compliance purposes. Vendors may charge a fee for user support.

6.4 ACM Vendor Demonstration

The Commission may request ACM vendors to physically demonstrate their program's capabilities. One or more demonstrations may be requested before approval is granted.

Chapter 7: Non-Residential Duct Installation Verification And Diagnostic Testing Using Home Energy Rating Systems (HERS)

7.1 Verified Duct Efficiency Improvements

The Commission has approved algorithms and procedures for determining duct and HVAC distribution efficiency for non-residential single-zone individual packaged equipment serving 5000 ft^2 or less via ductwork in the space between an insulated ceiling and the roof. Details of the energy efficiency calculations are presented in Appendix G.

There are two calculation procedures to determine seasonal air distribution efficiency using either: 1) default input assumptions, or 2) diagnostic measurement values. Air distribution efficiencies for heating and cooling shall be calculated separately. The ACM shall require the user to choose values for the following parameters to calculate seasonal duct efficiencies: duct insulation level and duct leakage level. The ACM shall use the defaults shown in [brackets] for the Standard Design and for the Proposed Design when the user does not enter a specific value for these parameters.:

1. Insulation level of ducts [R 4.2]
2. The leakage level of the duct system [22% of fan flow]. Two values are possible: the default or 8% of fan flow if measured and verified at no more than 6% of fan flow.

When any duct efficiency credit is claimed beyond the default assumptions that requires diagnostic testing or verification by a HERS rater or the local enforcement agency, i.e. when non-default values (except HVAC equipment capacities) are used to determine duct efficiency, the leaks in the air distribution system connections shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands and this requirement must be specified as required by the Nonresidential Manual. The ACM shall automatically use the following values from the description of the *Proposed Design* when calculating the distribution system efficiency:

- Number of stories
- Building Conditioned Floor Area
- Building Volume
- Outdoor summer and winter design temperatures for each climate zone

When more than one HVAC system serves the building, the HVAC distribution efficiency is determined for each system and a conditioned floor area-weighted average seasonal efficiency is determined based on the inputs for each of the systems.

When an existing HVAC system is extended to serve an addition, the default assumptions for duct and HVAC distribution efficiency must be used for both the *Proposed Design* and the *Standard Design*. However, when a new, high efficiency HVAC distribution system is used to serve the addition or the addition and the existing building, that system may be modeled to receive energy credit subject to diagnostic testing and verification of proper installation by a HERS rater.

7.2 California Home Energy Rating Systems

The Commission is required to regulate home energy rating system (HERS) providers in California. These regulations appear in the California Code of Regulations, Title 20, Chapter 4, Article 8, Sections 1670-1676). Approved HERS providers are authorized to certify raters and maintain quality control over ratings. Ratings are based on visual inspection and diagnostic testing of the physical characteristics and energy efficiency features of buildings, as constructed.

When compliance documentation indicates field verification and diagnostic testing of specific energy efficiency improvements as a condition for those improvements to qualify for Title 24 compliance credit, an approved HERS provider and certified HERS rater shall be used to conduct the field verification and diagnostic testing. HERS providers and raters shall be considered special inspectors by building departments, and shall demonstrate competence, to the satisfaction of the building official, for the visual inspections and diagnostic testing. The HERS provider and rater shall be independent entities from the builder or subcontractor installer of the energy efficiency improvements being tested and verified, and shall have no financial interest in the installation of the improvements

7.3 HERS Required Verification and Diagnostic Testing

HERS diagnostic testing and field verification is required for:

- duct air sealing
- augmented duct insulation

These features shall be listed as *HERS Verification Required* features on the *Performance Certificate of Compliance* (PERF-1) and the *Mechanical Compliance Summary* (MECH-1), and *Mechanical Distribution Summary* (*Certificate of Field Verification and Diagnostic Testing* (MECH-5)). Such verification constitutes “eligibility and installation criteria” for these features. Field verified and diagnostically tested features must be described in the *Compliance Supplement*.

7.4 Installation Certification

When compliance includes duct sealing, builder employees or subcontractors shall:

- complete diagnostic testing, and
- certify on the *Certificate of Field Verification and Diagnostic Testing* (MECH-5) the diagnostic test results and that the work meets the requirements for compliance credit.

When compliance credit has been claimed for duct insulation levels beyond those covered by default assumptions, builder employees or subcontractors shall record on the *Certificate of Field Verification and Diagnostic Testing* (MECH-5) the R-values for supply and return ducts.

Installer certifications are required for each and every building.

7.5 HERS Verification Procedures

HERS field verification and diagnostic testing shall be completed for each building. Field verification and diagnostic testing for compliance credit for duct sealing shall use the diagnostic duct leakage from fan pressurization of ducts in Section 4.3.8.2 of Appendix G. The HERS rater shall use the same fan flow basis as was used by the installer to calculate percentage duct leakage.

7.6 Responsibilities and Documentation

7.6.1 Builder

Builder employees or subcontractors responsible for completing either diagnostic testing, visual inspection or verification as specified in Section 7.4 shall certify the diagnostic testing results and that the work meets the requirements for compliance credit on the *Certificate of Field Verification and Diagnostic Testing* (MECH-5).

The builder shall provide the HERS provider with the identifying location of the building to receive diagnostic testing and the expected date that testing may begin. The builder shall provide the HERS provider a copy of the *Certificate of Field Verification and Diagnostic Testing* (MECH-5) signed by the builder employees or sub-contractors certifying that diagnostic testing and installation meet the requirements for compliance credit.

The builder shall provide a *Certificate of Field Verification and Diagnostic Testing* (MECH-5) signed and dated by the HERS rater to the building official in conjunction with requests for final inspection for each building.

7.6.2 HERS Provider and Rater

The HERS provider shall maintain records of all buildings tested, corrective actions taken, and copies of all *Certificate of Field Verification and Diagnostic Testing* (MECH-5) forms for a period of five years.

The HERS rater providing the diagnostic testing and verification shall sign and date a *Certificate of Field Verification and Diagnostic Testing* (MECH-5) form certifying that he/she has verified that the requirements for compliance credit have been met. The HERS rater shall provide this certificate to the builder and the HERS provider.

The HERS rater shall not sign a *Certificate of Field Verification and Diagnostic Testing* (MECH-5) form for a building that does not have a *Certificate of Field Verification and Diagnostic Testing* (MECH-5) form signed by the installer as required in Sections 7.4 and 7.6.1.

7.6.3 Building Department

The building department at its discretion may require independent testing and field verification in conjunction with the building department's required inspections, and/or observe the diagnostic testing and field verification performed by builder employees or subcontractors and the certified HERS rater in conjunction with the building department's required inspections to corroborate the results documented in installer certifications, and in the *Certificate of Field Verification and Diagnostic Testing* (MECH-5) form.

For buildings that have used a compliance alternative that requires field verification and diagnostic testing, the building department shall not approve a building for occupancy until the building department has received from the builder a *Certificate of Field Verification and Diagnostic Testing* (MECH-5) form that has been signed and dated by the HERS rater.